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Blended learning in higher education: Trends and capabilities

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Abstract
Education is a complex system that requires multiple perspectives and levels of analysis to understand its contexts, dynamics, and actors' interactions, particularly concerning technological innovations. This paper aims to identify some of the most promising trends in blended learning implementations in higher education, the capabilities provided by the technology (e.g., datafication), and the contexts of use of these capabilities. This literature review selected and analyzed *forty-five* peer-reviewed journal articles. The findings highlight some common capabilities among digital educational technologies. In particular, digital tools or platforms with human-to-machine interaction capabilities may enhance automated processes for blended learning delivery modes. In this context, digital technologies such as video capsules and intelligent tutoring systems may improve learning-teaching activities. First, by providing access to more students and facilitating self-paced online learning activities. Second, by offering an individual path of learning for each student, thus improving out-of-class activities and feedback. Educational technology capabilities (ETC) provide complementary insights to identify the best approach when aligning learning goals in technology-based implementations. Further research will be required to empirically validate these results.

Keywords Blended learning · Capabilities · Conceptual paper · Digital educational technology · Higher education · Trends

1 Introduction

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has identified education as a main societal priority, while acknowledging serious problems still not solved, especially in developing countries. UNESCO associates access to quality education with highly positive impacts in terms of income distribution and

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the creation and distribution of human prosperity. UNESCO proclaimed three principles within the framework *Education 2030*. The first principle restates the right to an education as a fundamental human right, as well as an enabling right. The second principle reaffirms education as a public good. Finally, the third principle prioritizes gender equality and inclusion in education as a global initiative for future years (UNESCO 2016). Social, economic, political, and cultural contexts represent both barriers and enablers that go beyond technological solutions as the only transformative elements in the education system.

Despite all efforts, most societies and education systems have failed in both elements of the first principle. In this context, technology is promoted as an effective mechanism for reducing inequality in education (Graham 2016, as cited in Selwyn 2011). Graham (2016) identified three ways in which people see technology as a facilitator of inclusion and equality in education: 1) increasing the diversity of mechanisms and modes in education; 2) decreasing barriers to education as a democratization mechanism; and 3) enhancing individual control over one's own education in terms of content, delivery mode, and pace of learning. These promises have not yet been fulfilled despite massive investments in content production and educational technologies such as Open Educational Resources (OERs) and Massive Open Online Courses (MOOCs).

Currently, worldwide demand for higher education is increasing despite frequent critiques related to high costs, accessibility barriers, dropout rates, and the quality of courses (OECD 2014). Furthermore, educational institutions often face challenges related to the overall relevance of their programs to graduates' continuing education or post-graduate employment (Christensen et al. 2011); and to the actual educational credentials in the higher education system (Collins 2011). Some of these challenges include: improving multicultural integration, reducing dropout rates, facilitating fluid transitions from educational programs to first jobs, and implementing flexible and relevant lifelong learning processes. To confront these challenges, Redecker and Puni (2013) as cited in Scott (2015), suggest that institutions require innovative structural transformations. However, these challenges must first be investigated through broader, multidisciplinary, multi-level research that addresses the social, pedagogical, economic, demographic, and financial aspects of education (Geels 2005). In this regard, approaches such as blended learning may provide alternative opportunities for higher education institutions to deal with these challenges and respond to external pressures to effectively deploy technological innovations in the classroom.

In general terms, blended learning integrates traditional, face-to-face classroom instruction with online digital learning. Programs in this modality are increasingly being adopted in higher education institutions and are clear examples of technological, pedagogical, and organizational innovation in universities. By 2007, almost 50% of four-year institutions in the U.S. offered courses in blended learning (Parsad et al. 2008, as cited in Arbaugh 2014). This rapid diffusion of blended learning has led to considerable research about its impact on learning performance, student outcomes (Torrisi-Steele and Drew 2013), and teaching pedagogy (Gerbic 2011). This impact will depend on how universities manage change with respect to the implementation of blended learning initiatives, as well as how they continue to support these systems once implemented.

The literature shows technology as a complex element operating in a varied set of educational settings. In this scenario, it is not the technology, but instead how it is used that drives the transformational process in blended learning implementations. Furthermore, information (as a key element in innovation adoption and diffusion processes) is required throughout the entire innovation process, firstly to identify the need for innovation, and secondly to evaluate implementation outcomes (Rogers 2003). According to Selwyn (2011), one of the biggest challenges in implementing new technologies is the difficulty of measuring their impact on the educational system. In most cases, these implementations show a pattern of inconsistency in the use of technology. As a result, the effects and outcomes of implementing technologies in educational contexts are uncontrolled and not predictable (Laumakis et al. 2009). Additionally, Fagerberg et al. (2009) assert that individual and organizational learning processes are historically path-dependent, which constrains how new blended learning implementations can be deployed.

Research about these transformations often involves performing analyses of future technological trends and their impact, which typically involve different periods of time to develop a potential impact analysis (Selwyn 2011). The short- and medium-term concern a detailed state-of-the-art description, while the long-term corresponds more to speculative forecasting. In education, this type of analysis involves groups of learners in classrooms and institutions, as well as the entire educational ecosystem. This paper aims to identify trends in literature about blended learning implementations in higher education, the capabilities provided by the technology, and the contexts of use of these capabilities.

This paper is divided into seven sections: The first section presents concepts related to educational technologies, their capabilities, and their use in blended learning implementations. The second section presents the conceptual framework and research questions. It is followed by sections dealing with the research method and the finding and results. Finally, the paper presents a discussion section, some policy implications for the educational sector, conclusions, limitations of the current analysis, and suggestions for future research work.

2 Concept definitions

For the purpose of this paper, the author defines *digital educational technology* (DET) as all digital technologies designed or used for learning and teaching activities in formal or informal educational contexts. This concept is based on previous definitions related to technology, digital technology, and educational technology. These three definitions allow the author to identify the boundaries of digital educational technologies for this study. First, technology, as defined by Lievrouw and Livingstone (2002), comprises the designed, built, and deployed artifacts or devices; the enabled practices associated with their use; and all social and institutional aspects and structures circumscribed in their use. Second, digital technology is defined as "computer-based systems" in a broad perspective including contemporary software and hardware systems with the purpose of handling digital information (Selwyn 2011). Finally, The author identified educational technology as all technology, digital or otherwise, designed, created, and applied to the education process (Dutton 2013).

Digital technologies improve some basic characteristics of data and information, including storage, record retrieval, distribution, density and compressibility, manipulability, and user control (Sydenham and Thorn 2005). These improved characteristics allow digital technologies to alter the way users interact with their environment, and thus these characteristics give digital technologies the possibility to offer capabilities such as convergence, integration, crowdsourcing, personalization, ubiquity, measurability, and (ideally) democratization of access to education (Tiwana 2014). These characteristics and capabilities may allow digital technologies such as computers, the Internet, adaptive software platforms, mobile computing, and technological platforms to become enablers for organizational transformations (Berger 2015; Christensen et al. 2009). Nevertheless, these technological enablers also require alignment with organizational enablers to be effective. Data and information-intensive processes in higher education institutions may act as potential organizational enablers for transforming existing products or services into more advanced technological products (Tiwana 2014).

Educational technology capabilities (ETC) are defined as a set of common abilities present in different digital technologies enabling a set of learning purposes (e.g., personalization). The main assumption is that capabilities are built on a distinctive combination of technological characteristics and tool functionalities. Thus, capabilities may be present in various tools and one tool may provide multiple capabilities. This perspective may present ETCs as a mechanism for evaluating and comparing technology implementations and their transformational potential. Figure 1 presents a conceptual model representing the relationship between digital technology characteristics, tools and platforms functionalities, and capabilities in educational technology.

Finally, blended learning considers content and instructional delivery methods as key elements for providing better learning experiences (Garrison and Kanuka 2004). These methods comprise face-to-face classroom instruction with online digital learning with appropriate integration and balance. However, blended learning lacks a precise definition which often hinders analyses of its implementations and comparisons

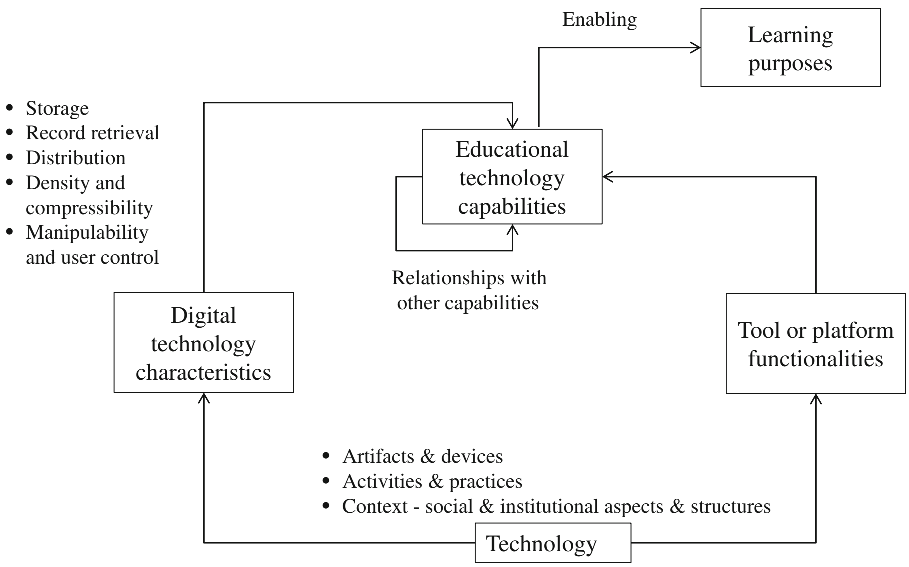

Fig. 1 Conceptual model of technology capabilities

between implementation outcomes (Picciano 2009; Tshabalala et al. 2014). In one recent attempt to overcome this problem, Fernandes et al. (2016) provided a more refined definition which is the selected definition for this research. They state that blended learning integrates the use of learning theories and teaching practices in a "flexible, multimodal and multi-linear redesign", whereby multi-linear learning refers to self-paced and individualized learning processes.

3 Conceptual framework and research questions

Technology dynamics, as a complex process, requires a broader conceptual framework for its analysis (Geels 2005, 2011). This study uses Geels' multi-level perspective on sustainability transitions to guide the understanding of technology adoption, diffusion, and educational practice transformations in different levels of the higher education system. This framework allows describing the transitions of the novelty diffusion between levels of a socio-technological system in order to identify patterns and trends in the technological development process analyzed in literature.

Currently, digital technology applications in higher education are numerous and varied, but their impact on education is uneven. Academic and practitioner research presents these applications from different perspectives, trends, and levels of analysis. These analyses focus mainly on evaluating learner outcomes; analyzing students' and faculty members' dispositions and preferences; comparing implementations from different delivery methods; and general interaction among students and instructors (Halverson et al. 2014). However, little research on blended learning implementations in higher education has focused on: 1) identifying research trends from a multiple-perspective approach and 2) challenging main assumptions about capabilities of educational technology. Based on the selected scientific literature regarding blended learning in higher education, the author performed a content analysis to identify some of the most promising trends and capabilities in educational technology. Identifying these trends and capabilities in educational technology and describing how instructors can use these capabilities in a blended learning environment in higher education is the aim of this research. In order to achieve these goals, the author chose the following research questions:

1. What are the emerging trends in blended learning implementations in higher education?
2. What are the current capabilities in the educational technology used in these blended learning implementations in higher education?
3. How are these educational technology capabilities used in blended learning implementations in higher education?

These questions highlight digital technology as an enabler for improving or transforming learning activities. In particular, this research focuses its attention on identifying the most promising educational technology capabilities and the contexts of their use. Most blended learning literature focuses its attention on specific digital tools or platforms rather than on distinctive capabilities that technology may offer for a smoother alignment with pedagogy.

The author also bases his analysis on the three main elements discussed by Christensen (1997). These elements include: 1) the technological enabler, which normally refers to sophisticated technologies that allow for the simplification and automation of organizational processes; 2) the business model innovation, which may allow for an organization to deliver services to customers in ways more suitable to their needs; and 3) the value network, which is the commercial infrastructure network or ecosystem built by an organization or set of organizations. These elements may allow higher education organizations to understand the transformation dynamics related to technology-based innovations from an institutional perspective. All these elements include a coordinated effort to understand and align strategies, capabilities, and roles for each player in higher education institutions. In this context, organizational transformations require not only technological enablers, but also organizational enablers (Christensen 1997) in order to deploy their transformational potential. Thus, transformations may fail or take a long time if organizational strategies do not take account of the entire industry ecosystem (Adner and Kapoor 2010; Christensen et al. 2009; Koza and Lewin 1998).

4 Method

The author structured this research using a literature-based approach to concept development (Branch and Rocchi 2015). In the first phase, the author performed a purposive and iterative search to identify the most relevant articles in the social, organizational, technological, and pedagogical literature. Table 1 presents the list of keywords and search terms that were used for identifying a final set of *forty-five* relevant studies using the search engines ERIC, EBSCO, SCOPUS and Web of Science. The references resulted of this search were limited to English-language peer-reviewed scientific journal articles about blended learning implementations in higher education.

Two technological tools were selected for managing the research data: EndNote for organizing literature references and ATLAS.ti for handling data from the qualitative analysis. The author applied a qualitative content approach to analyze and synthesize the data collected for each perspective. During this process, some initial themes related to potential trends and educational technology capabilities were identified. Additional iterations allowed the author to refine the list of capabilities and usage contexts reported in literature. The author structured the findings

Table 1 Keywords and search terms

Categories	Keywords and search terms
Blended learning	"Blended learning", "blended education", "hybrid learning", "mixed-mode instruction".
+ Higher education	"Higher education", university*, college.
+ Innovation adoption and diffusion	Adopt*, barrier*, challenge, change*, diffusion, disruption, driver, factor, impact*, improvement, innovation, innovativeness, invention, pattern, radical, redefining, reinvention, restructuring, sustainable, transform*.

(* indicates to the database to search/retrieve the string with any ending) and results in two subsections: trends in educational technologies and educational technology capabilities. During the coding and note-taking process, the list of capabilities was refined and the usage contexts were detailed. These findings allowed the author to provide a more precise definition of the concept of *technological capability* and served as the basis for the discussion and conclusions.

5 Findings and results

5.1 Research trends in selected literature about digital technologies in blended learning for higher education

This paper uses the terms *trends* to describe certain patterns, paths, trajectories, or orientations that technologies or related aspects may follow. These trends describe various approaches and purposes in selected literature that relate to: strategic responses of education institutions to technological challenges; pedagogical frameworks or practices in classroom contexts; research trends in the sociology of education and technology; and classifications of educational technologies. This study uses the varied and heterogeneous set of trends to identify common characteristics in digital technologies producing capabilities when used in educational contexts. These capabilities may provide some criteria to describe the transformational potential of these digital technologies. This multiple-perspective analysis provides insight into educational technology capabilities at different levels of analysis and into how these capabilities are used in educational contexts. Table 2 summarizes findings from this section.

5.1.1 Research trends from a social perspective

General societal aspects, including educational principles, economic policies, and cultural values, are main elements of the sociotechnical landscape analysis (Geels 2005). Some of these aspects are also considered trends in research in the emerging field of the sociology of education and technology. Selwyn and Facer (2014) identified and classified most of these elements and their related problems in four main trends: 1) the reconfiguration of space, time, and responsibility; 2) the individualization of education; 3) the study of educational inequalities; and 4) the educational contexts where technology is used.

The first trend relates to the human-to-human technology-mediated interactions among actors in the educational system regarding aspects of space, time, and responsibility. The second trajectory relates to the individualization of education. In these trends, capabilities such as datafication, human-to-machine interactions, and personalization may provide the required technological support to assure specific and individualized paths for each student. The third and fourth trends relate to the study of educational inequalities and the educational contexts where technology is used. Articles related to these trends analyze technologies with respect to educational access describing social principles such as the democratization of education; and uncovering structural societal problems. Technologies identified in these trends may provide capabilities, such as scalability, that higher education institutions cannot provide using existing resources. However, these technologies have not produced the expected results in terms

Table 2 Identified research trends in selected literature

Research trends from a social perspective (Section 5.1.1)	Research trends from an organizational perspective (Section 5.1.2)	Research trends from a technological perspective (Section 5.1.3)	Research trends from a pedagogical perspective (Section 5.1.4)
- Reconfiguration of space, time, and responsibility - Individualization of education - Educational inequalities Educational contexts	- Adoption and diffusion of innovations - Unbundle global academic programs and curriculum for local institutions - New alliances and changes in the credential system - Lifelong learning - Bring your own device (BYOD)	- Learning Management Systems (LMSs) - Learning Space - Textbook vs. OER - Device ownership & Mobile first - Adaptive Learning Technology - Learning Analytics - Flexible Infrastructure	- Student-centered approaches - Active learning - Personalized learning - Peer collaborative learning - Flipped classrooms - Communities of inquiry
Authors (Examples)			
(Selwyn and Facer 2014)	(Graham et al. 2013) (Torrisi-Steele and Drew 2013) (Adner and Kapoor 2010) (Brett 2011) (Collins 2011)	(Siemens 2013) (Chang and Liu 2013)	(Hoic-Bozic et al. 2016) (Ginns and Ellis 2009), (Garrison and Arbaugh 2007)

of quality, appropriateness, and acceptance in higher education institutions, despite their accelerated development.

5.1.2 Research trends from an organizational perspective

Most organizational approaches to blended learning are concerned with technological innovations, institutional practices, inter-institutional interactions, and the impact of technological policies (Garrison and Kanuka 2004). Research in blended learning as an organizational innovation enabled by technological development focuses on two main streams. The first stream comprises studies using theoretical frameworks related to the adoption and diffusion of technological innovations. The second stream reports technology implementations at institutional levels, particularly strategic responses to technological challenges. These studies show different analyses of the challenges, barriers, benefits, and drivers behind the adoption of blended learning innovations. As Torrisi-Steele and Drew (2013) have stated, innovations may require more than simply embedding technology into current teaching and learning practices. The literature shows the following as the most promising trends: unbundling academic programs and curriculums in local institutions (Kleß and Pfeiffer 2013); and implementing strategies to respond to the accelerated and diverse change in technologies, such as bring your own device (BYOD) (Brett 2011).

Higher education institutions struggle with constraints to produce or access content for specialized courses in a cost-effective way. These limitations provide the basis for the development of the *unbundling academic programs and curriculums* trajectory. Although technologies and resources such as MOOC platforms, open educational resources, and commercial digital content provide the necessary functionalities to enable this trajectory, real-world implementations must still contend with many organizational and policy challenges. Digital platforms, as currently implemented, may not be real competitors in the higher education system, especially in the face of well-established non-profit institutions. However, the convergence of all these aspects in strong platforms may create a complementary relationship for credential-granting among educational institutions, multi-sided platforms (e.g., Coursera and edX), and digital content publishers (e.g., Pearson Education). In this scenario, courses from universities and MOOC platforms may facilitate the unbundling of university-level academic curriculums. However, there is still a low institutional acceptance of these new solutions when it comes to granting academic credits (Collins 2011).

On the other hand, the use of smartphones and tablets is rapidly growing as students are bringing these personal devices to classrooms and campuses. These devices are opening pathways for trends such as BYOD (Brett 2011). This modality brings new challenges for institutions due to the diverse spectrum of technologies not considered or supported in their strategies regarding technical support and staff knowledge. Despite the diversity of these trends, this analysis identified some common educational technology capabilities comprising the interactions between learners and instructors with digital devices and platforms, the ability to provide specific and individualized content to multiple learners, and the ability to offer these services on a larger scale.

5.1.3 Research trends from a technological perspective

Numerous articles describe technologies that are likely to impact the education ecosystem in the short- and medium-term. These descriptions usually lead to classifications regarding technological purposes or main functionalities. The literature analyzed shows a set of research trends in digital technologies about blended learning in higher education implementations such as: next generation of learning management systems (Yang et al. 2014), adaptive textbook and OER (El-Ghareeb and Riad 2011), learning analytics (Siemens 2013), adaptive learning technology (Foshee et al. 2016), digital devices ownership and mobile learning (Brett 2011), and learning spaces (Chang and Liu 2013). Complementary to these trends, findings also state the need for flexible and integrated technological infrastructures as major components for allowing interoperability.

On the one hand, most technology-based educational initiative, typically, do not use the full potential of the implemented technologies. Most e-learning and blended learning implementations use learning management systems (LMSs) solely as teaching management or content delivery tools without any true pedagogical transformation of courses (Woods et al. 2004, as cited in Torrisi-Steele and Drew 2013). Nevertheless, due to their high level of adoption in academic institutions, these platforms may play an important role extending their capabilities and moving toward the next generation of learning management systems. The next step in online content delivery continues with MOOCs. This technological development is presented as creating a shift from local institutional platforms to a global-scale development, and thus, according to their promoters, toward a more democratic access to quality education. However, to date, MOOCs have not achieved their desired impact.

On the other hand, interactive and scalable online textbooks and OERs extend LMS and MOOC capabilities to provide better educational content. These technologies, by exploiting educational data analysis, may improve learning-teaching processes. Siemens (2013) defines learning analytics as the "*measurement, collection, analysis, and reporting of data about learners and their context, for the purposes of understanding and optimizing learning and the environments in which it occurs*." These technologies and capabilities may provide better assessment and feedback processes, and also serve as the basis for personalization using automated tutoring systems.

Mobile computing devices offer a new convergence point for digital technologies in hardware and software. These robust devices have the capacity to run most personal computer software. Their reliable operating systems offer a set of sophisticated functionalities and an open platform for application development, thus constantly improving their personalization capabilities. These devices are also facilitating access to existing systems or platforms, including LMSs and MOOCs. Furthermore, in conjunction with immersive technologies, such as virtual reality (VR) and augmented reality (AR), they provide the capability to create new learning spaces. Traditionally, classrooms, laboratories, and learning commons provided the required environment for learning-teaching processes; however, digital technologies are transforming other physical spaces, such as museums, into learning spaces (Chang and Liu 2013). Finally, the lack of integration, interoperability, and convergence characteristics in systems and platforms are also reported as barriers to technological innovations. In this context, further successful blended learning implementations require a flexible and robust technological infrastructure to support them. In particular, for higher levels of institutionalized adoption (Graham et al. 2013).

5.1.4 Research trends from a pedagogical perspective

Instructors, teachers, and institutions incorporated available learning theories and technologies into the learning process and were met with clear indications of learning improvement, but not disruptive transformations. Most trends identified in articles from a pedagogical perspective comprise frameworks, models, and practices at individual and group levels such as student-centered approaches, active learning, personalized learning, peer collaborative learning, flipped classrooms, and communities of inquiry.

Practices at the individual level include learning differentiation and personalization, multiple intelligence types, learning styles, self-paced learning, and synchronous and asynchronous learning activities (Foshee et al. 2016). Practices at the group level include cognitive, teaching and social presence as core elements of the *communities of inquiry* (Shea and Bidjerano 2010). In these communities, according to Garrison and Arbaugh (2007), a group of learners engage in collaborative work, creating an adequate space for meaningful learning experiences. Among these approaches, *personalization*, *learner-centered,* and *enhancing learners' motivation and engagement* seem to be the *most promising* for implementing technology in educational contexts. McLoughlin and Lee (2008) argue that the principles of *personalization*, *participation*, and *productivity* are the basis for instruction in the twenty-first century. Personalization as a solution to a standardized and mass-oriented education system is attracting the attention of commercial and open-initiative digital technology producers. This approach bases its development in digital technologies such as *Learning Analytics* and *Big Data*, digital content delivery, adaptive learning platforms, and mobile computing. The convergence of these technological approaches facilitates the development of more complex and flexible learning tools.

Other approaches intend to improve learning outcomes and motivation, as well as the successful transfer of knowledge within the learning process. Particularly in terms of digital literacy, Littlejohn et al. (2012) contend that some technology promoting peer learning activities has a positive effect on learners' engagement and motivation. However, teachers' skills not only in virtual class sessions, but also in in physical classrooms may enhance or undermine learners' *motivation and engagement*. Therefore, it is important to explore the entire educational system and its components to better understand the barriers to, and drivers of, learners' motivation and engagement. This understanding is an essential prerequisite to the incorporation of new technologies as potential solutions in the learning-teaching process.

Finally, despite these collaborative and supportive social contexts, digital technologies also provide individualized and personalized practices. These practices may also offer the educational constructivist model the tools required to prioritize the learner as the center of the process rather than the instructor (McLoughlin and Lee 2008). However, aligning these apparently contradictory pedagogical approaches and technologies is a major challenge for instructors when redesigning their courses.

5.2 Educational technology capabilities

Based on the selected literature, the author analyzed technology from the perspectives identified in the previous section. This analysis focused on common characteristics of the technology (e.g., data collection) producing specific capabilities when used in educational contexts (Table 3). This section presents these educational technology capabilities providing a detailed explanation about how these capabilities are used in blended learning implementations for higher education contexts.

5.2.1 Datafication

Datafication refers to the use of automated tools, technologies, and processes for data collection, analysis, and reporting to improve the design and deployment of learning-teaching activities. Findings show improvement in learning-teaching activities when aligning pedagogical approaches (e.g., student-centered or flipped classrooms) with existing student's information on educational tools. Collecting this information may take place in the classroom as well as pre-class online. When deployed, these processes (e.g., online assessment tools) offer instructors information about students' knowledge gain and difficulties. This information may be used for providing automated and instantaneous personalized assessments and out-of-class feedback (Francis and Shannon 2013), or group in-class feedback. The process of collecting data may also be performed during in-class sessions when using online tutorials, or specific assessment tools such as audience response systems (ARS). When using ARS, instructors may intend to assess the knowledge level of the class, and also to enhance interaction among learners (Masikunas et al. 2007).

Traditional tools such as LMSs and MOOCs may also provide datafication capabilities; however, these are still immature technologies with regard to this capability. In some cases, (e.g., LMS platforms) this capability provides mechanisms for analyzing students' behavior or learning difficulties, and thus can deliver appropriate content (Martin and Whitmer 2016). In other cases, datafication may help instructors to identify students' performance when analyzing data from multiple systems (Khawaja et al. 2013), particularly for automated assessment and feedback processes (Nakayama et al. 2010).

Tools providing this capability use technological approaches, such as learning analytics and big data, to add value to existing practices. These approaches may provide the basis for creating customized learning paths for students either in individual or group activities. These activities may cover in-class lectures (El-Ghareeb and Riad 2011), as well as out-of-class activities (Hsieh and Wu 2013). Initial findings show differences in the level of detailed information and expertise when instructors use educational technologies. The patterns in these differences seem to be associated with the maturity of the implementation with regard to the instructor's expertise and the organizational level of adoption (e.g., course-level, academic department, institution).

5.2.2 Human-to-human technology-enabled interactions

The capability of human-to-human interaction facilitates online collaborative activities, peer review, and synchronous or asynchronous communication and is one of the most

Table 3 Educational technology capabilities

Capability	Rationale	Main themes in selected studies
Datafication	Capabilities for data collection, data analysis, and data-driven design and decision processes.	Audience response systems (ARS) (Masikunas et al. 2007), adaptive functionalities in LMS platform (Martin and Whitmer 2016), automated assessment and feedback systems (Nakayama et al. 2010).
Human-to-human technology-enabled interactions	Capabilities for technology-mediated human interactions, mainly with online collaborative activities, peer-review assignments, and synchronous or asynchronous communication.	LMS, web 2.0 technologies, and a recommender system (RS) (Hoic-Bozic et al. 2016).
Human-to-machine interactions	Capabilities providing higher levels of interactivity and automation. Systems can be considered active actors in the learning-teaching process.	Intelligent tutoring systems (Khawaja et al. 2013), virtual companion systems and recommender systems (Hsieh and Wu 2013), wearable devices, and mobile technologies.
Immersive experience	Capabilities providing the sense of experiencing alternative simulated realities by mixing physical and digital worlds aspects for enhancing collaboration, motivation and engagement.	Digital games (Bahji et al. 2015), immersive virtual simulators (IVS) (Kleinert et al. 2015), augmented reality, RFID, and mobile devices (Chang and Liu 2013), virtual worlds technology (Pellas and kazanidis 2014, 2015).
Scalability	Capabilities providing automated resources for attending higher demands of services in cost-effective ways.	Online adaptive tutorials (Bai and Smith 2010), LMS (Greyling et al. 2008), MOOC (Gynther 2016), adaptive learning systems (Foshee et al. 2016).

studied in the literature surrounding blended learning. It relates mostly to online discussion forums, social networking systems, online conference tools, instant messaging, chat rooms, and email tools among other technologies. Although these technologies provide space and time independence in communication and collaborative activities, no studies report substantial transformation in current practices. However, implementations integrating human-to-human, technology-enabled interactions, and other capabilities, such as datafication, with specific design considerations present some level of transformation.

Findings show that, despite initial flexible designs, a permanent iterative adjustment is required to align data-driven activities and academic students' needs analysis. For example, (Li and Chen 2009) identified that appropriate complexity in assignments, learners' diversity, and learners' interactions design are essential elements for improving learning outcomes. In this context, a recommender system is proposed as a solution to reduce post-class assistance sessions. This system promotes peer collaboration for technical questions and answers based on automatic recommendation functionalities, thus showing improvement in completion rates for coursework assignments. Additionally, (Hoic-Bozic et al. 2016) investigated the impact of technology-based collaboration and personalized knowledge sharing strategies in a computer science program. The main technological components of these problem-based learning strategies are based on LMS, web 2.0 technologies, and a recommender system. This system comprises several recommendation options, including: optional learning activities, peer-collaborative assignments, suitable web 2.0 tools, and individual or group advice. These authors reported on the effectiveness of the implementation, student satisfaction, and also on improvements in learning outcomes. Additionally, they reported no increase in teaching loads due to these iterative planning and execution activities. These activities were designed and performed in a small class context; nevertheless, as they assert, they can be extended to large classes with some changes in the type of activities and the number of group participants.

Finally, complexity in face-to-face human interactions is also present in online environments. The author identified a few studies analyzing negative effects in this technology-enabled learner-to-learner interaction. (Dursun and Akbul 2012) explored the relationship between cyberbullying behaviors and communicator styles in anonymous learner-to-learner interactions using web 2.0 technologies. Literature shows different negative elements depending of the type of technology. These authors identified a set of cyberbullying types not presented in their study, but already identified and analyzed in other studies using different technologies for interactions such as online gaming and social networking. These findings show that educational technology capabilities may also block or impede blended learning implementations when potentially troublesome issues are not considered in course designs or adjusted during the process.

5.2.3 Human-to-machine technology-enabled interactions

Systems with human-to-machine interaction capabilities integrate characteristics such as interactivity, interoperability, automation, and technological convergence. Interactive systems and platforms with artificial intelligence functionalities offer new alternatives for tutoring activities based on intensive assessment and feedback, particularly for large courses. Technologies such as intelligent tutoring systems (Khawaja et al. 2013), virtual companion systems (Hsieh and Wu 2013), immersive virtual simulators (Kleinert et al. 2015), wearable devices, and mobile technologies present clear examples of these kinds of interactions.

Learner-to-machine interactions are becoming more relevant in the scientific literature, which primarily analyzes educational automation processes. Studies in this category reported results on learning performance, knowledge gain improvement, and students' motivation. Hsieh and Wu (2013) reported learning performance improvements using virtual learning companion systems (VLCS) and also analyzed their alignment with students' cognitive styles. Likewise, in clinical education, Kleinert et al. (2015) stated that immersive virtual simulators (IVS) showed positive effects in knowledge gains and motivation. However, no positive impacts on clinical decision-making processes were observed. According to Kleinert et al. (2015), this may be related to the number of options available in the system. They argue that a better design of the system is required to promote improvements in clinical decision-making processes and student performance. Finally, technologically mature systems offering this capability may become active actors in the learning process.

Activities that the literature reports as potential targets for automation comprise: tutoring, assessment, feedback, and content delivery. These activities provide individualized learning paths for each student. Technologies providing this capability include online adaptive content and tutorials, virtual companion systems, learning activities recommender systems, and intelligent tutoring systems. The following examples show how and in what contexts instructors are using adaptive technologies to provide personalization.

First, Khawaja et al. (2013) presented an adaptive tutoring system based on intensive assessment and feedback in large-size courses. Among other things, this tutorial allowed for adapting tasks, content, feedback, assessment, and remediation for each student and showed a general improvement in learning outcomes. Likewise, Bai and Smith (2010) proposed a scalable and sustainable set of digital content modules and an intent to investigate their usability. The module containing assessment activities can be delivered independently of the technological platform. They assert that this solution provides collaborative functionalities and a cost-reduction strategy for academically disadvantaged students in under-resourced communities.

Second, as Hsieh and Wu (2013) analyze, VLCSs and e-learning activities recommender systems show improvements in learning performance and, as a result, align students' cognitive styles and guidance methods. These systems may also offer specific and complementary adaptive functionalities for learning purposes. VLCSs were initially used for children's entertainment and medical assistance. Recommender systems allow for combining some pedagogical approaches such as student-centered, personalized, collaborative, and problem-based learning. (Hoic-Bozic et al. 2016), in a comparative study of engineering courses using this kind of technology, analyzed the effectiveness of these approach's alignment. This implementation showed improvement in students' learning outcomes as a result of this integrative model's implementation.

Third, technological developments in LMSs' adaptive functionalities and artificial intelligence-based platforms show some improvements in scalability and quality of computer-based individualized learning processes. In terms of competency development, (Yang et al. 2014), based on their experimental results, argue that contextual and adaptive instruction improves critical thinking skills and English literacy, which are two twenty-first century competencies. In this case, they analyzed some adaptive functionalities of Moodle for grouping activities, organization, and personalized content delivery and feedback based on information gathered from a pre-test. Additionally, the literature describes large-size and teacher-centered classrooms as potential candidates for higher levels of improvement when deploying technologies providing personalization (Danker 2015), particularly when aligned with pedagogical approaches such as flipped classrooms. This kind of approach may promote individualized learning and facilitate self-paced pre-class activities (Danker 2015), peer support, one-on-one tutoring for in-class activities (El-Ghareeb and Riad 2011), or group tutoring in in-class activities (Kleinert et al. 2015).

5.2.4 Immersive experience

Immersive experience is a capability that provides learners with the sense of immersion by combining aspects of physical and simulated digital worlds. Peer learning and collaborative activities are the most common pedagogical approaches with respect to technologies providing this capability. Some examples of these technologies are augmented reality, virtual worlds (e.g., Second Life), and virtual reality systems. Bahji et al. (2015) present these technologies as mechanisms for enhancing engagement and motivation in the learning process and for improving students' support and competency development (Kleinert et al. 2015).

Examples of these kind of implementations, particularly for virtual world technologies, describe their use in course evaluations (Ata 2016). Other authors have analyzed: how in-class learning activities promote interaction and collaborative environments (Tapsis et al. 2012); how these technologies affect students' learning behavior (Mitchell and Forer 2010); and the effects of virtual worlds on students' achievements by measuring students' motivation (Pellas and kazanidis 2014). In another example, creating a new learning space, Chang and Liu (2013) assessed the acceptance of a system promoting a ubiquitous learning environment and its impact on learning outcomes. By using technologies such as augmented reality, radio-frequency identification (RFID), and mobile devices, the system provides physical spaces with learning environment capabilities. According to them, learners' acceptance level of the system was high, particularly with regard to the quality of the animation and technology integration.

Actual developments in technologies related to this capability show that they are used in educational contexts as a support for traditional practices, but with low levels of maturity in their use. However, potential benefits for pedagogical practices are also described in these studies as highly transformational. Findings also show an interesting blurred boundary between informal and formal spaces for learning acquisition, particularly when transforming physical spaces, such as museums, into interactive, immersive learning spaces.

5.2.5 Scalability

The scalability capability may provide required automated resources for higher levels of service demand in a cost-effective manner. In educational contexts, this capability has at least two dimensions: First, providing a means to attend to different students' needs in or out of large classes in a flexible and individualized way (Khawaja et al. 2013). Technology in this dimension may improve learning processes by scaling an instructor's capacity to attend to students' academic needs (e.g., intelligent tutoring systems). Second, providing a means for creating, bundling, unbundling, and deploying digital content in multiple platforms to facilitate content access and sharing activities among instructors and institutions (e.g., LMS and MOOC).

For the first dimension, Khawaja et al. (2013) analyzed the impact of adaptive tutoring systems on learning outcomes based on intensive assessment and feedback for large-size courses. These authors reported "less satisfactory results" in the data analyzed. They assert that elements related to activities such as cognitive load, influence final learning outcomes. These elements may be refined for particular contexts to assure appropriate levels of academic assignments (Khawaja et al. 2013). On the other hand, Danker (2015) analyzed the impact of flipped classrooms and individualized learning on deep learning among students in large size and diverse classes. According to this author, flipped approaches can provide active-learning activities for small groups within a large lecture class. These approaches based on self-paced pre-class activities facilitate tutoring activities during the class.

For the second dimension, Bai and Smith (2010) provide an example with their "scalable, shareable, and sustainable e-learning modules as textbook chapters." Students and instructors can access these modules independent of the platform. Technologies such as LMS, MOOC, and adaptive learning systems may provide this capability. Gynther (2016) presents a clear example when proposing and analyzing the use of a framework for an adaptive MOOC in blended learning contexts. This implementation responded to a requirement of the Danish government to offer a Bachelor's degree for school teachers. This framework is based on general design principles for personalized curriculum and adaptive learning design. Despite their findings showing good implementation results, these results also showed low peer support and demonstrated a need for increasing teacher presence.

Finally, findings showed some relationships between technology capabilities. For example, in some instances, datafication can be considered as a foundation to allow personalization and human-to-machine interactions. In others, personalization may not be possible without scalability. This interrelated nature requires further research to uncover the specific contexts and the level of dependence.

6 Discussion

The literature analyzes blended learning implementations mainly from two different perspectives. First, from a general perspective identifying the effects, barriers, challenges, drivers, and opportunities affecting the entire organization or system. Second, from a more specific point of view identifying how particular technological tools or platforms impact learning-teaching activities. Units of analysis relate to different levels of deployment such as classrooms, organizational implementations, or national initiatives framed by governmental policies. Each implementation comprises a large and diverse set of learning-teaching practices, instructor expertise levels, pedagogical frameworks, technological tools, and organizational and cultural values forming very complex and unique educational settings. The main contributions of this paper are: 1) the identification of the most promising trends in blended learning implementations in higher education, 2) the identification of some capabilities provided by the technology (e.g., datafication), and 3) the analysis of the contexts of use of these capabilities.

The set of identified trends provided the author an initial insight into common educational technology capabilities present in different digital technologies. The educational technology capability concept analyzed in this study seems also suitable as a crosswise analysis tool for understanding transformation processes in a multi-level perspective. As a first step, this paper analyzed the identified technological trends in order to identify patterns about distinctive characteristics in digital educational technologies that could produce a major change in the education system. In a second step, this paper identified some usage contexts of educational technologies presented in higher education institutions related to these capabilities.

For particular digital technologies such as LMSs, extensive information exists about their successful institutional adoption. Dahlstrom et al. (2014) present statistics showing that 99% of higher education institutions in the U.S. are operating LMSs, where 85% of instructors use it at least once in its basic functionality, and 47% use it daily in their courses. On the one hand, Moodle (for example) can be used for different purposes depending on an instructor's expertise and needs. The basic level offers a repository of content that is available for download. An intermediate level may correspond to a more interactive communication and knowledge-sharing platform. Finally, a higher level may use adaptive functionalities of this platform. However, personalization as an educational purpose enabled by human-machine interactions capabilities in LMSs are still at lower levels when compared with more adaptive platforms such as Knewton. On the other hand, tools or platforms may present low levels of technology development. For example, when LMS platforms integrate adaptive functionalities in basic levels of development or with very restrictive functionalities (Perišić et al. 2018).

Different technologies may provide the same capability; however, such capability may present different levels of technological development in various technological tools or platforms. In the case of the human-machine interaction capability, current LMSs provide basic levels of adaptive functionalities that translate into a personalized learning path for each student. Other platforms (e.g., Knewton) use sophisticated artificial intelligence-based tools to improve the scalability and quality of computer-based individualized learning processes. Although initial commercial products were technologically insufficient to create a useful and scalable system (Selwyn 2011), current developments in digital educational content platforms and in adaptive learning systems may allow for the creation of integrated, individualized, and scalable learning environments.

Universities and colleges present remarkable differences in course-level content and curriculums for similar academic programs. These differences may also hinder more scalable solutions to the entire higher education system. Nevertheless, among other elements, these differences provide distinctive institutional characteristics and potential scenarios for innovations. For example, institutions present differences regarding the delivery of highly codified and stable content to first-year students and students in more advanced stages of academic programs. As Thomson (2016) proposed, eventually all first-year courses may benefit from digital technologies allowing the transformation of these courses into online-only delivery mode. These kinds of technologies with human-to-machine interaction capabilities may also provide more automated delivery processes for blended learning delivery modes. In this context, digital technologies such as video capsules and intelligent tutoring systems may improve learning-teaching activities. First, by scaling access to more students and facilitating self-paced online learning activities. Second, by providing an individual learning path for each student, thus improving out-of-class activities (Hsieh and Wu 2013) and feedback (Francis and Shannon 2013).

On the other hand, these technologies may not provide appropriate solutions for advanced courses where knowledge is less stable and standardized. For these kinds of courses, digital technologies with human-to-human technology-enabled interactions capabilities, such as intelligent recommender systems, may enhance interactions among learners in collaborative learning environments. In this context, this system is proposed as a solution to reduce instructors post-class assistance sessions. This system promotes peer collaboration for technical questions and answers based on automatic recommendation functionalities (Li and Chen 2009).

This study has defined educational technology capabilities as a set of common abilities present in different digital technologies enabling a set of learning purposes. These capabilities show different levels of maturity and these levels are characterized by two aspects. The first aspect relates to differences in the development level of the technological tools and the second aspect relates to the level of instructor expertise in using a particular technology and aligning pedagogy to potentiate the design of the learning-teaching activities. This exploratory analysis shows higher levels of transformation in pedagogical practices when technological tools or platforms show higher levels of maturity or when multiple capabilities are successfully aligned with learning goals during the implementation.

Finally, these findings may be explained by a better understanding of the alignment between technology and pedagogy, and by a reinforcing effect when several capabilities are interacting and providing more refined implementations. As a result, educational technology capabilities as a concept may provide an alternative and broad perspective for analyzing and improving not only the level of alignment of pedagogy and technology, but also a technological investment strategy. In this scenario, various implementations with different technologies may be analyzed and compared with respect to cost-effectiveness, instructor and organizational expertise, and technological development level. However, further research is required to provide more detailed insights and validate these findings.

7 Policy implications

Different digital tools and platforms used in educational contexts may provide the same educational technology capability despite their differences in some specific functionalities. Deploying, using, and managing various tools or platforms imply an increase in economic investment, support time, and permanent training processes for students, instructors, and faculty members interested in using these tools in their learning-teaching activities. Educational technology capabilities as a conceptual tool for analyzing future technological implementations may facilitate policy makers and practitioners to prioritize institutional efforts in blended learning implementations. This mechanism provides some insights about redundancy and wasteful investments in time and economic resources for acquiring and deploying digital technology in higher education institutions.

8 Conclusions

This paper attempts to identify some of the most promising trends in educational technology, in the capabilities provided by the technology (e.g., datafication), and in the contexts of use of these capabilities in blended learning implementations in higher education.

In order to answer the proposed research questions, this study analyzed the literature related to technological implementations in a higher education context, specifically for blended learning delivery. This multi-perspective analysis identified a set of existing trends that allowed the author to refine a list of capabilities that new technologies may offer in educational contexts. Educational technology capabilities, defined as a set of common abilities present in different digital technologies enabling a set of learning purposes, may provide a distinctive mechanism for evaluating and comparing technologies and their transformational potential in course-level or institutional implementations. In the process of identifying how instructors use these capabilities, patterns about potential relationships among them were uncovered. However, this being an exploratory study, not all pertinent aspects were covered and further research will be required on these questions.

Many challenges have arisen due to the rapid development of technology in response to social demands, and the current digital transformation has created new pressures for higher education systems. The introduction of MOOCs and other digital technologies has highlighted the controversies and problems of educational systems around the world. These new technologies have created an enormous interest among universities and companies offering educational content and alternative technological solutions, allowing the rapid growth of network alliances among these actors. However, digital technologies still have not addressed several major social problems (e.g., high costs, high accessibility barriers, high dropout rates, and low course quality) related to education as envisioned by many in the academic community. There remains a gap for structural and technological solutions to create a democratic, decentralized, and personalized education system that succeeds in engaging the majority of students.

In this scenario, alternative mechanisms for analyzing and evaluating technology-based implementations are required to gain better insight into the process and its transformational potential. This analysis identified educational technology capabilities as a crosswise concept independent from specific technological tools and perspectives of analysis. This exploratory research provided a definition for a technological capability and presented a conceptual model describing the identified relationships between technologies, technological characteristics, and educational technology capabilities. Specifically, this framework intends to contribute to the analysis and evaluation of blended learning implementations in higher education, presenting educational technology capabilities as an alternative and transversal concept. This concept may help researchers and practitioners gain a better understanding of the nature of the relationship between technology, pedagogy, organization, and society in general in a multi-level perspective analysis.

9 Limitations and future research directions

This exploratory research has several limitations. First, as this paper performed a purposive and iterative search, some relevant articles could not be identified and included. However, this search provided *forty-five* relevant sources, thus assuring an appropriate level of comprehensiveness. Second, the multiple perspective of analysis provided a broader set of sources that enriched the search strategy; however, these heterogeneous sources made it difficult to reach conceptual saturation when searching and selecting additional literature.

Future research could explore additional trends identified in social, organizational, technological, and pedagogical perspectives as a mechanism for validating the findings and refining the set of educational technology capabilities identified in this paper. Researchers might also analyze and summarize empirical studies with regard to educational technology capabilities in order to validate the propositions about capability maturity levels for the technological development and user expertise dimensions. Further research might also focus on identifying factors and barriers promoting or impeding higher capability maturity levels in blended learning implementations. Finally, a map of digital technologies based on a typology of capabilities may provide great value for practitioners and their future implementations.

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Compliance with ethical standards

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References

Studies included in the literature review

Arbaugh, J. B. (2014). What might online delivery teach us about blended management education? Prior perspectives and future directions. *Journal of Management Education, 38*(6), 784–817.

Ata, R. (2016). An exploration of higher education teaching in second life in the context of blended learning. *Turkish Online Journal of Educational Technology, 15*(3), 9–26.

Bahji, S. E., El Alami, J., & Lefdaoui, Y. (2015). Learners' attitudes towards extended-blended learning experience based on the S2P learning model. *International Journal of Advanced Computer Science and Applications, 6*(10), 70–78.

Bai, X., & Smith, M. B. (2010). Promoting hybrid learning through a sharable eLearning approach. *Journal of Asynchronous Learning Networks, 14*(3), 13–24.

Brett, P. (2011). Students' experiences and engagement with SMS for learning in higher education. *Innovations in Education and Teaching International, 48*(2), 137–147. https://doi.org/10.1080/14703297.2011.564008.

Chang, Y. H., & Liu, J. (2013). Applying an AR technique to enhance situated heritage learning in a ubiquitous learning environment. *Turkish Online Journal of Educational Technology - TOJET, 12*(3), 21–32.

Collins, R. (2011). Credential inflation and the future of universities. *Italian Journal of Sociology of Education, 2*, 24.

Danker, B. (2015). Using flipped classroom approach to explore deep learning in large classrooms. *IAFOR Journal of Education, 3*(1), 171–186.

Dursun, Ö. Ö., & Akbul, Y. (2012). Communicator style as a predictor of cyberbullying in a hybrid learning environment. *Turkish Online Journal of Qualitative Inquiry, 3*(3), 118–131.

El-Ghareeb, H., & Riad, A. (2011). Empowering adaptive lectures through activation of intelligent and web 2.0 technologies. *International Journal on E-Learning, 10*(4), 365–391.

Foshee, C. M., Elliott, S. N., & Atkinson, R. K. (2016). Technology-enhanced learning in college mathematics remediation. *British Journal of Educational Technology, 47*(5), 893–905.

Francis, R., & Shannon, S. J. (2013). Engaging with blended learning to improve students' learning outcomes. *European Journal of Engineering Education, 38*(4), 359–369. https://doi.org/10.1080/03043797.2013.766679.

Garrison, D., & Arbaugh, J. B. (2007). Researching the community of inquiry framework: Review, issues, and future directions. *Internet and Higher Education, 10*(3), 157–172. https://doi.org/10.1016/j.iheduc.2007.04.001.

Garrison, D., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education, 7*(2), 95–105. https://doi.org/10.1016/j.iheduc.2004.02.001.

Gerbic, P. (2011). Teaching using a blended approach–what does the literature tell us? *Educational Media International, 48*(3), 221–234. https://doi.org/10.1080/09523987.2011.615159.

Ginns, P., & Ellis, R. A. (2009). Evaluating the quality of e-learning at the degree level in the student experience of blended learning. *British Journal of Educational Technology, 40*(4), 652–663. https://doi.org/10.1111/j.1467-8535.2008.00861.x.

Graham, S. (2016). Bridging Urban Digital Divides? Urban Polarisation and Information and Communications Technologies (ICTs). *Urban Studies, 39*(1), 33–56.

Graham, C. R., Woodfield, W., & Harrison, J. B. (2013). A framework for institutional adoption and implementation of blended learning in higher education. *Internet and Higher Education, 18*, 4–14.

Greyling, F., Kara, M., Makka, A., & van Niekerk, S. (2008). IT worked for us: Online strategies to facilitate learning in large (undergraduate) classes. *Electronic Journal of e-Learning, 6*(3), 179–188.

Gynther, K. (2016). Design framework for an adaptive MOOC enhanced by blended learning: Supplementary training and personalized learning for teacher professional development. *Electronic Journal of e-Learning, 14*(1), 15–30.

Halverson, L. R., Graham, C. R., Spring, K. J., Drysdale, J. S., & Henrie, C. R. (2014). A thematic analysis of the most highly cited scholarship in the first decade of blended learning research. *Internet & Higher Education, 20*, 20–34. https://doi.org/10.1016/j.iheduc.2013.09.004.

Hoic-Bozic, N., Dlab, M. H., & Mornar, V. (2016). Recommender system and web 2.0 tools to enhance a blended learning model. *IEEE Transactions on Education, 59*(1), 39–44.
Hsieh, & Wu, M.-P. (2013). Exploring learning performance toward cognitive approaches of a virtual companion system in LINE app for m-learning. *Eurasia Journal of Mathematics, Science & Technology Education, 9*(4), 337–346.
Khawaja, M. A., Prusty, G. B., Ford, R. A. J., Marcus, N., & Russell, C. (2013). Can more become less? Effects of an intensive assessment environment on Students' learning performance. *European Journal of Engineering Education, 38*(6), 631–651.
Kleinert, R., Heiermann, N., Plum, P. S., Wahba, R., Chang, D. H., Maus, M., et al. (2015). Web-based immersive virtual patient simulators: Positive effect on clinical reasoning in medical education. *Journal of Medical Internet Research, 17*(11). https://doi.org/10.2196/jmir.5035.
Kleß, E., & Pfeiffer, A. (2013). The bologna process and its changes for the teacher education in rhineland-palatinate, Germany-media-education-online as an innovative example for statewide cooperation of universities. [Article]. *International Journal of Innovation and Learning, 13*(2), 218–232. https://doi.org/10.1504/IJIL.2013.052289.
Laumakis, M., Graham, C. R., & Dziuban, C. (2009). The Sloan-C pillars and boundary objects as a framework for evaluating blended learning. *Journal of Asynchronous Learning Networks, 13*(1), 75–87.
Li, L.-Y., & Chen, G.-D. (2009). A coursework support system for offering challenges and assistance by analyzing Students' web portfolios. *Educational Technology & Society, 12*(2), 205–221.
Littlejohn, A., Beetham, H., & McGill, L. (2012). Learning at the digital frontier: A review of digital literacies in theory and practice. *Journal of Computer Assisted Learning, 28*(6), 547–556. https://doi.org/10.1111/j.1365-2729.2011.00474.x.
Martin, F., & Whitmer, J. C. (2016). Applying learning analytics to investigate timed release in online learning. *Technology, Knowledge and Learning, 21*(1), 59–74.
Masikunas, G., Panayiotidis, A., & Burke, L. (2007). The use of electronic voting Systems in Lectures within business and marketing: A case study of their impact on student learning. *ALT-J: Research in Learning Technology, 15*(1), 3–20.
McLoughlin, C., & Lee, M. (2008). The three P's of pedagogy for the networked society: Personalization, participation, and productivity. *International Journal of Teaching and Learning in Higher Education, 20*(1), 10–27.
Mitchell, P., & Forer, P. (2010). Blended learning: The perceptions of first-year geography students. *Journal of Geography in Higher Education, 34*(1), 77–89. https://doi.org/10.1080/03098260902982484.
Nakayama, M., Yamamoto, H., & Santiago, R. (2010). The role of essay tests assessment in e-learning: A Japanese case study. *Electronic Journal of e-Learning, 8*(2), 173–178.
Parsad, B., Lewis, L., & Tice, P (2008). Distance education at degree-granting postsecondary institutions: 2006-2007. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://nces.ed.gov/pubs2009/2009044.pdf
Pellas, N., & Kazanidis, I. (2014). Engaging students in blended and online collaborative courses at university level through second life: Comparative perspectives and instructional affordances. *New Review of Hypermedia & Multimedia, 20*(2), 123–144. https://doi.org/10.1080/13614568.2013.856958.
Pellas, N., & Kazanidis, I. (2015). On the value of second life for Students' engagement in blended and online courses: A comparative study from the higher education in Greece. *Education and Information Technologies, 20*(3), 445–466.
Perišić, J., Milovanović, M., & Kazi, Z. (2018). A semantic approach to enhance moodle with personalization. *Computer Applications in Engineering Education, 26*(4), 884–901. https://doi.org/10.1002/cae.21929.
Picciano, A. (2009). Blending with purpose: The multimodal model. *Journal of Asynchronous Learning Networks, v13 n1*, p7–18.
Redecker, C., & Punie, Y. (2013). The future of learning 2025: developing a vision for change. Future Learning (Vol. 1, pp. 3–17).
Selwyn, N., & Facer, K. (2014). The sociology of education and digital technology: Past, present and future. *Oxford Review of Education, 40*(4), 482–496. https://doi.org/10.1080/03054985.2014.933005.
Shea, P., & Bidjerano, T. (2010). Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. *Computers & Education, 55*(4), 1721–1731. https://doi.org/10.1016/j.compedu.2010.07.017.
Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist, 57*(10), 1380–1400. https://doi.org/10.1177/0002764213498851.
Tapsis, N., Tsolakidis, K., & Vitsilaki, C. (2012). Virtual worlds and course dialogue. *American Journal of Distance Education, 26*(2), 96–109.

Torrisi-Steele, G., & Drew, S. (2013). The literature landscape of blended learning in higher education: The need for better understanding of academic blended practice. *International Journal for Academic Development, 18*(4), 371–383. https://doi.org/10.1080/1360144X.2013.786720.
Tshabalala, M., Ndeya-Ndereya, C., & van der Merwe, T. (2014). Implementing blended learning at a developing university: Obstacles in the way. *Electronic Journal of e-Learning, 12*(1), 101–110.
Woods, R., Baker, J. D., & Hopper, D. (2004). Hybrid structures: Faculty use and perception of web-based courseware as a supplement to face-face instruction. *Internet and Higher Education, 7*, 281–297.
Yang, Y., Gamble, J., Hung, Y., & Lin, T. (2014). An online adaptive learning environment for critical-thinking-infused English literacy instruction. *British Journal of Educational Technology, 45*(4), 723–747.

Methodological and complementary sources

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal, 31*(3), 306–333.
Berger, R. (2015). The digital transformation of industry. (pp. 52): The Federation of German Industries (BDI).
Branch, J., & Rocchi, F. (2015). Concept development: A primer. *Philosophy of Management, 14*(2), 111–133. https://doi.org/10.1007/s40926-015-0011-9.
Christensen, C. (1997). *The innovator's dilemma : When new technologies cause great firms to fail*. Boston: Harvard Business School.
Christensen, C., Grossman, J., & Hwang, J. (2009). *The innovator's prescription : A disruptive solution for health care*. New York: McGraw-Hill.
Christensen, C., Horn, M., & Johnson, C. (2011). *Disrupting class : how disruptive innovation will change the way the world learns (Updated and expanded new ed.)*. New York: McGraw-Hill.
Dahlstrom, E., Brooks, D. C., & Bichsel, J. (2014). The current ecosystem of learning management systems: Stutent, faculty, and IT perspectives. (27 ed., pp. 27).
Dutton, W. H. (2013). *The Oxford handbook of internet studies*. Oxford: Oxford University Press.
Fagerberg, J., Mowery, D. C., & Verspagen, B. (2009). Innovation, path dependency and policy : The Norwegian case. In *Oxford*. New York: Oxford University Press.
Fernandes, J., Costa, R., & Peres, P. (2016). Putting order into our universe: The concept of blended learning—A methodology within the concept-based terminology framework. *Education Sciences, 6*(2), 15.
Geels, F. W. (2005). Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. *Technological Forecasting and Social Change, 72*(6), 681–696. https://doi.org/10.1016/j.techfore.2004.08.014.
Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002.
Koza, M. P., & Lewin, A. Y. (1998). The co-evolution of strategic alliances. *Organization Science, 9*(3), 255–264.
Lievrouw, L. A., & Livingstone, S. M. (2002). *Handbook of new media : social shaping and consequences of ICTs*. London; Thousand Oaks [Calif.]: SAGE.
OECD (2014). Education at a glance 2014. *OECD indicators* (570 ed., pp. 570).
Rogers, E. M. (2003). *Diffusion of innovations*. New York: Free Press.
Scott, C. L. (2015). The futures of learning 1 - why must learning content and methods change in the 21st century? *UNESCO Education Research and Foresight* (13-Sep-2015 ed., Vol. 13, pp. 16).
Selwyn, N. (2011). *Education and technology : Key issues and debates*. London; New York: Continuum International Pub. Group.
Sydenham, P. H., & Thorn, R. (2005). *Handbook of measuring system design* (Vol. *1*). Chichester [u.a.: Wiley.
Thomson, D. I. C. (2016). How online learning will transform legal education. In F. X. Olleros & M. Zhegu (Eds.), *Research Handbooks on Digital Transformations* (pp. 23–38).
Tiwana, A. (2014). *Platform ecosystems aligning architecture, governance, and strategy*: Morgan Kaufmann Publishers.
UNESCO (2016). Education 2030, Incheon declaration and framework for action - towards inclusive and equitable quality education and lifelong learning for all. *UNESCO* (pp. 51).