Smart Learning Environments

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Active learning and education 4.0 for complex thinking training: analysis of two case studies in open education

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Abstract

This article focuses on empirically analyzing the final products designed by 147 academics from 11 countries who participated in an international open education movement workshop by answering the research questions "What are the techno-pedagogical components of the products designed by the participants to encourage the open educational movement? and what practice of the open educational movement is being executed?" The article starts with a conceptual basis that describes the concepts of Active learning, Education 4.0, Complex Thinking and Open Education. It presents (1) the case study methodology on which this research is based, (2) two case studies on open education, (3) a game-based intervention proposal to support instructors in training university students in complex thinking skills based on Education 4.0 technologies and game-based learning principles, (4) and a discussion of the findings and opportunities for further work in the area. The findings of this study reveal that (A) the use of emerging and 4.0 technologies in initiatives of the open education movement continue to increase; (B) most of the open education initiatives designed by academics participating in the workshops were focused on the production of OER; and (C) inclusive access to education and continuing professional development of teachers is a constant concern addressed in open education initiatives. The results of this research suggest that training and development interventions implying the creation or design of open education initiatives should focus on encouraging all kinds of open education practices (i.e. use, production, dissemination and mobilization).

Keywords: Higher education, Complex thinking, Active learning, Game-based learning, Open education, Education 4.0

Introduction

The new student-centred educational paradigm for learning has led to reformulating the classroom environment and the teaching approach, so that students are able to acquire knowledge by themselves. In this sense, open education is associated with collaborative educational practices within learning communities that allow progress towards a culture of exchange and active learning for students. The promotion of open education can be done through different learning strategies, one of which is gamification. In open education, Open Educational Resources (OER) are considered potential sources to bring

active learning. Likewise, there are technological enablers of education 4.0 to promote these open educational practices. Through sophisticated active learning strategies, these resources and enablers provide opportunities for students to develop reasoning for complexity, understood as a strategy that globally helps to understand the characteristics of the phenomena of today's society, intertwining and linking its components. These concepts are detailed below.

Active learning

Active learning definition and characteristics

Active learning suggests that students must do more than just listen: they must be actively involved in the learning process. Active learning is usually defined as a student-centered approach to teaching and learning (Lee, 2018). Students must read, write, discuss, and engage in higher-order thinking tasks such as analysis, synthesis, and evaluation (Bonwell & Eison, 1991; Felder & Brent, 2009). Lebrun (2007) provides an inventory of the characteristics of active pedagogy that includes: the personal nature of learning; the catalytic role of prior knowledge; the motivational factors; the importance of the available resources; the role of context, environment and concrete experience; the high-level skills to be exercised; the research approach and questioning in learning; the conceptual change (awareness, imbalance, reformulation); the need for feedback on one's activities; the interactive and cooperative nature of learning; the link between personal, professional, study and life projects; the importance of construction, and production; and the role of reflection on the learning process. For students to participate in the learning process, they must use the content knowledge, not just acquire it.

Teaching techniques that involve students in the learning process, and strategies promoting active learning refer to instructional activities involving students in doing things and thinking about what they are doing (Bonwell & Eison, 1991). Several strategies or instructional activities promoting active learning have influenced students' attitudes and achievements. For instance, in-class writing is considered a productive way to involve students in doing things and thinking about what they are doing while discussion in class is one of the most common strategies promoting active learning (Bonwell & Eison, 1991). Other popular strategies are problem-solving, collaborative learning, cooperative learning, project-based learning, case study method of instruction, guided design, debates, drama, role-playing and simulation (Bonwell & Eison, 1991; Felder & Brent, 2009; Lebrun, 2007; Lee, 2018). In this study, we focus on game-based activities for learning.

Active learning is associated with socio-cultural models, recognizing that knowledge is socially constructed with others. Sampedro et al. (2022) provide an innovative methodology of collaborative and responsible learning in Philosophy of Law, with inverted classroom, problem-based learning, blended learning, collaborative work, gamification and peer assessment, contributing to improving academic results and student satisfaction. Da Silva Garcia et al. (2022) also experimented with multiple active methodologies (virtual learning environments, coding, gamification, problem-based learning, flipped classroom and serious games) in an algorithms subject, finding improvements in results when using the proposed approach. Integrating technologies, such as the technology tool Kahoot, promotes active learning (Gravalos-Gastaminza et al., 2022). In India,

strategies to foster group cohesion in online learning environments were developed through crossword puzzles and hybrid medical Pictionary (Hirkani et al., 2022). In this way, collaboration, self-regulation and social construction become vital elements in fostering active learning.

Active learning and game-based learning (GBL)

Active learning is distinguished by fostering hands-on experiences with cognitive, motivational and constructivist strategies, such as game-based learning (GBL). GBL and gamification are emerging innovative methodologies scarcely used in higher education (Greipl et al., 2020). These methodologies use games to acquire educational competencies through directed educational learning, providing a practical experience for students (Almalki, 2022). If digital games hosted in a platform with a solid theoretical-methodological structure are also chosen, they can provide more complete training solutions, contributing to digital literacy through ICT (Tay et al., 2022). The Activity Theory supports these methodologies, which offer a dynamic and dialectical view of the educational process (Noroozi et al., 2020). More specifically, they propose the gradual internalization of learning through tasks within a virtual environment that organizes them to positively guarantee conceptual advances, simultaneously establishing optimal communication, collaboration, and reflection formulas.

In their role as innovation potentiators, universities have transformed teaching by giving students an active role in environments where games are used for learning. The effectiveness of digital game-based learning in students has been studied in comparison with other instructional methods and taking as variables the subject or subjects, the educational level, the game design, and the duration of the intervention (Gris & Bengson, 2021; Wang et al., 2022). Dabbous et al. (2022) evidence learning in experiential pharmacy education, through game-based activities that promoted the better achievement of motivation and learning outcomes. Also, in the field of architecture, Pons-Valladares et al. (2022) applied active strategies in the Architecture 360 project, applying blended learning, challenge-based learning, reflective learning, videos of actual cases, case studies, site visits, interactive simulation, and gamification, finding that active alternatives improved implementation, including didactic materials made available by teachers and dedication outside the classroom. In particular, the use of serious games is a strategy in the field of GBL, primarily used in online teaching; findings from their implementation reflect increased motivation and engagement (Arias-Calderón et al., 2022; Willis & Bryant, 2022). From this perspective, GBL can lead to experiencing real and strategically designed scenarios.

Active learning and gamification

The design of gamification experiences must foster participation with research actions, self-management, collaboration, and creativity. Unlike GBL, which consists of supporting learning using a game with specific rules and objectives, gamification involves learning experiences designed using game mechanics and characteristics found in traditionally non-game environments (Cornellá et al., 2020). For example, using an educational board game to review the key concepts of a subject during class represents a GBL intervention while using a points system or badges (i.e., game elements) to reward

students in a class setting for their performance in an exam or their behavior is an example of gamification. In both cases, it has been demonstrated that they are attractive and motivating methodologies, with a positive impact on student learning and feedback (Bawa, 2022; Coleman & Money, 2020). Polyakova and De Ros Cócera (2022) designed gamification-based learning experiences for professional growth in teacher training seminars that included experimentation (workshop, training materials), feedback (questionnaire, discussion), analysis and dissemination of results, resulting (with a questionnaire application), in the construction of new gamified knowledge and increased awareness of active learning techniques. Reverse learning with gamified processes has also been designed to assess standard and structured active learning, finding the latter to have better learning outcomes (Jones & Sturrock, 2022). Other designs with gamification have involved computational thinking learning processes for non-computer science students, where participation in active learning activities was a stronger determinant of learning outcomes than initial knowledge; furthermore, gamification of computational notebooks may serve as a driver of active learning engagement, even more so than initial motivational factors (De Santo et al., 2022). Designing active experiences with gamification can support critical thinking processes and generate new ideas by being aware of the knowledge gains.

Education 4.0

Universities play a relevant role in achieving the Sustainable Development Goals (SDGs) developed and adopted by the United Nations General Assembly (United Nations, 2015) and are critical actors in achieving the fourth SDG by carrying out innovative solutions to develop inclusive, equitable, and quality education. To successfully achieve this required transformation, the 2030 Agenda proposes the creation of partnerships and synergies among the international actors involved to accelerate processes and perfect solutions to common problems where technology offers greater possibilities for connection, inclusion, and access (United Nations, 2015). Although none of the SDGs explicitly refer to information and communication technologies, they recognize the need to leverage educational technology approaches to reduce the digital divide and develop knowledge societies (Rodríguez-Abitia et al., 2020). Following the analysis of case studies on implementing the SDGs in higher education institutions internationally, Zhou et al. (2020) emphasized the need to seek strategies based on technological innovation to ensure their integration into academic and professional development. Among this typology of strategies, Lane (2017) and Ahel and Lingenau (2020) point out that a higher education system properly regulated, designed, and supported by technology, open educational resources (OER), and distance education modalities increase access, equity, quality, and relevance of education, consequently leading to the achievement of the SDGs. Concerning this, technological 4.0 enablers contribute to boosting open education.

Education 4.0 refers to leveraging modern infrastructure and emerging technologies to improve higher education pedagogical procedures (Miranda et al., 2021). In other words, Education 4.0 is the integration of advanced technologies such as artificial intelligence, virtual and augmented reality, into the education system, with the purpose of creating more personalized, collaborative, and technology-enhanced learning experiences,

and preparing students for the future workforce (Bonfield et al., 2020). Miranda et al. (2021) propose a classification of Education 4.0 technologies: (1) technology-based solutions that incorporate working principles of technologies and techniques such as Artificial Intelligence and Machine Learning, Data Science, Virtual Imaging Processing, Data Analytics and Cloud Computing; and (2) tools and platforms that refer to emerging technology-based solutions that combine different technologies for educational and management purposes such as web conference technologies (e.g., ZOOM, Meets, Webex, M-Teams) and asynchronous learning platforms (e.g., Learning Management Systems). Education 4.0 relies on a differentiating element from previous paradigms based on the application of existing information and communication technological tools, including the predominant role of students, the bilateral integration and cooperation among the various agents of educational actions, and the opportunities to build content under the concept of "learning by doing" (Bonfield et al., 2020; Hong, 2020). According to Papert (2020), learning is grounded in contexts, and it is shaped by external tools and supports through mediation. For him, constructionism is a construct that views learning as building knowledge structures through internalization when the learner is consciously engaged in constructing a public entity (Papert, 2020). In this sense, Education 4.0 provides learning environments enabled by technologies where learners are consciously engaged with different interactive supports.

González-Pérez et al. (2022) point out six technological 4.0 enablers that guide educational actors to enhance educational innovation and open education: open technologies, digital pedagogies, adaptive technologies, smart technologies, technological innovation models and disruptive technologies. Fidalgo-Blanco et al. (2022) verified that students had acquired competencies by integrating active hybrid methodology with 4.0 technologies. Integrating these technological enablers in education invites innovative practices in the teaching–learning process such as those based on gamification (Mohd Arif et al., 2020). There have been educational experiences in which the effectiveness of gamification in instilling university students' commitment to education 4.0 has been proven (Ab Rahman et al., 2019; Mohd Arif et al., 2019). At the same time, the limitations of teaching innovation projects in higher education based on gamification under the paradigm of education 4.0 have been pointed out, such as the simplification of the real world by these applications, the difficulties of integration into the didactic system and the offer of greater interactivity without predefined external stimuli (Almeida & Simoes, 2019).

Complex thinking

Complex thinking definition

Complex thinking is a desired competency in university students and future workers to face the challenges of Twenty-first-century workplaces and social spaces. As a construct, it refers to various higher-order thinking skills that provide a person with the tools to confront real problems as an individual or a social agent integratively and holistically (Morin, 1986, 2005). It is impossible to understand complex thinking without considering the concept of complexity. If complexity represents the world as an extensive network formed by fine threads that intertwine and connect its components, then complex thinking is the ability of an individual to apply integrative thinking when solving a problem; it is a strategy or way of thinking that has a globalizing

or encompassing intention toward the phenomena but, at the same time, recognizes the specificity of the parts (Morin, 1986). Complex thinking is opposed to disciplinary division; it promotes a transdisciplinary and holistic approach without abandoning the notion of the constituent parts of the whole; and it focuses on establishing relationships and complementarities (Morin, 1994, 2005).

In this study, complex thinking is considered a meta-competency that comprises four higher thinking skills: (1) critical thinking, (2) systemic thinking, (3) scientific thinking, and (4) innovative thinking (Ramirez-Montoya et al., 2021; Vazquez-Parra et al., 2022).

- Systemic thinking promotes solving problems by considering the elements of the system through the integrative analysis of its parts and the interpretation of data from different interrelated fields of science (Jaaron & Backhouse, 2018; Oliveira et al., 2020).
- Scientific thinking enhances problem-solving and provides answers to questions about real-world situations by applying objective, valid, and reliable methodologies, analyzing data and using reasoning strategies or cognitive processes, such as inductive and deductive reasoning, problem-solving, and formulating and testing hypotheses (Koerber et al., 2015; Suryansyah et al., 2021; Zimmerman & Croker, 2014).
- Critical thinking is the process of conceptualizing, applying, analyzing, synthesizing and evaluating information obtained or generated by observation, experience, reflection, reasoning or communication to assess the soundness of one's and others' reasoning to form one's own judgment of a situation or problem (Sellars et al., 2018; Straková & Cimermanová, 2018).
- Innovative thinking involves the ability to analyze or interpret the context; apply creativity to design, create or generate solutions; and reflect and evaluate the proposed solution so that it leads to improvements and social progress (Wheeler, 2006; Wisetsat & Nuangchalerm, 2019). See Fig. 1.

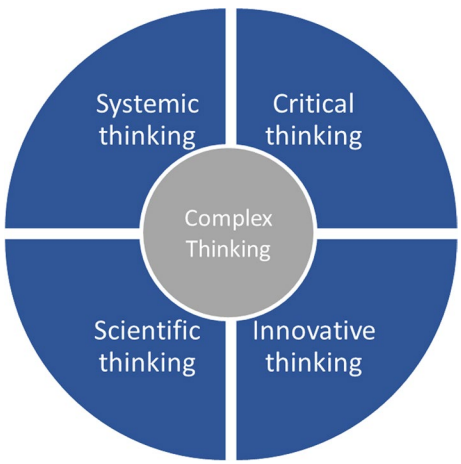

Fig. 1 Complex thinking construct

Active learning and complex thinking

Active learning strategies can drive complex thinking, where critical thinking is substantial to face uncertainty in changing phenomena. Pinto and Marín (2021) studied the relationship between active learning and the insertion into the labor market of nursing students, identifying security aspects related to acting in the labor market; the active method stimulated proactivity and initiative for learning and helped overcome the difficulties in teamwork and lack of experience in particular specialized fields. Bruna (2013) postulated that student-centered pedagogy could achieve motivation and enhance learning in new students enrolled in courses that require complex thinking and involve different subjects. Similarly, Kellogg and Karlin (2012) provided a holistic student-centered approach to support the attributes of the 2020 Engineer which includes a culture that embraces intellectual diversity, and improved team, problem-solving, and complex thinking skills. In the same vein, Ruiz Loza et al. (2022) provided active learning experiences using ad-hoc technology applications as an essential resource to reinterpret the learning process and shift the focus toward skills development through active learning. Active learning can foster complex thinking to build a sustainable society through developing competencies in leadership, innovation, entrepreneurship, and sustainability awareness (Desai, 2012). In this sense, the reasoning for complexity involves working in uncertain situations that require problem-solving, with active actions that promote shifting the focus and foster dynamic processes.

Open education

The Open Educational Movement emerged in the early 2000s, aiming to share information to reduce the gap between communities with access to information and those with difficulties accessing it. In the United States, OpenCourseware, characterized by freedom of use, made available by universities such as the Massachusetts Institute of Technology (MIT) appeared on the Internet and led to the creation of the open movement. One of its manifestations is the OER, free and open digitalized materials for educators, students, and self-learners to use and reuse in teaching, learning and research (Butcher et al., 2011). The Open Educational Movement is a phenomenon that has been developed and analyzed, mainly in Europe and the United States (Ramirez-Montoya, 2013). Given the importance for Latin American countries to have high-quality materials, courses and resources, several academics and researchers there have focused on studying and following up on experiences in the use, reuse and transfer of knowledge in the open access area (Burgos & Ramírez-Montoya, 2010).

In this study, we define the open educational movement as open access educational activities that enable educational practices including using OER available on the Internet, producing openly licensed materials, disseminating practices in academic, governmental, and institutional, environments, and mobilizing educational practices. In other words, the open educational movement refers to practices, resources, and open-access technologies that involve the production, use, dissemination, and mobilization of training (Ramirez-Montoya, 2020). Open Education and OER are relevant to smart learning environments since they promote accessibility, and flexibility through OER delivery mechanisms. On the one hand, Educational 4.0 technological enablers to promote open

education within the framework of UNESCO recommendations include open technologies, digital pedagogies, adaptive technologies, intelligent technologies, technological innovation models, and disruptive technologies (González-Pérez et al., 2022). On the other hand, smart education is considered as a growing emerging field of research that represents the integration of (a) smart systems and environments; (b) smart technologies; (c) state-of-the-art educational programs and tools; (d) innovative pedagogies, teaching strategies and learning methodologies based on advanced technology (Uskov, 2015). A smart learning environment "features the use of innovative technologies and elements that allow greater flexibility, effectiveness, adaptation, engagement, motivation, and feedback for the learner" (Darsham-Singh & Hassan, 2017: 9). In this sense, many OER are either delivered by smart technologies, smart systems and environments or constitute teaching strategies and learning methodologies based on advanced technology. For instance, Ghallabi et al. (2022) proposes an architecture with reusable components to create a personalized learning system that generates courses adapted to learner's characteristics. The aim of this study is to analyze the final products designed by academics to encourage the open education movement.

Materials and method

This work adopts a case study research approach for data collection and analysis. Case study research has been widely used in educational research to enhance the understanding of contexts, communities, and individuals (Hamilton & Corbett-Whittier, 2013). Case studies can provide in-depth exploration of complex phenomena in real-life settings since they focus on institutional culture, particular groups, teaching methods, or behaviors (Merriam, 1988). According to Yin (2009), exploratory case studies like the ones we present in this paper are characterized as the collection of data and subsequent looking for patterns in the data. Six sources of evidence can help build a case: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (Yin, 2009). The cases presented in this study rely on documentation, archival records, and direct observations. For its analysis, a qualitative strategy interested in description and interpretation has been followed.

Research questions

This article focuses on empirically analyzing the cases and the final products designed by academics participating in an international open education movement workshop to answer the following research questions:

RQ1 What are the techno-pedagogical components of the products designed by the participants to encourage the open educational movement?
RQ2 What practice of the open educational movement is being executed?

Data analysis

To provide answers to the previously mentioned research questions, we analyzed the collected data and classified it into categories that describe (1) the technological

components of the products designed by the participants that emerged from the data and (2) the practice of open education (Ramirez-Montoya, 2020) as described below:

- Use refers to using or implementing existing OER for research, teaching, and learning purposes.
- Production refers to combining diverse material and immaterial inputs to make or create OERs for open educational purposes.
- Dissemination refers to the targeted distribution of information, resources, practice, and intervention materials to a specific audience with the intent to spread knowledge and evidence-based interventions related to the open education movement.
- Mobilization refers to the act or process of organizing OER or preparing repositories for encouraging people to take action and use, produce, disseminate, or mobilize OER.

Case studies

Specifically, this study presents cases emanating from research in the Latin American community. The article describes the attributes of each case and analyzes (1) the objectives, (2) the activities, (3) the methodology and (4) the final products. See Table 1 for a summary of each case.

The case of the 2019 UNESCO Chair for open educational movement in Latin America workshop

The international workshop on the open education movement was held from December 9 to 20th, 2019, at Tecnologico de Monterrey (Campus Monterrey, Mexico). The topics of interest addressed during the stay included the Open Educational Movement, Open Training Practices, Open Technologies and Repositories, Open Innovation, Open Science, Open Networks and Sustainability of Education (Ramirez-Montoya, 2019).

Participants 70 academics from 11 countries (Chile, Colombia, Costa Rica, Ecuador Peru, Spain, United States, England, Mexico, Nicaragua, Dominican Republic) participated in the UNESCO 2019 international stay of the Open Educational Movement for Latin America. Table 2 presents the role of participants and their country of origin.

Objectives The main objective was to analyze experiences of the open education movement and the integration of innovative methodologies, through an international workshop with speakers and specialists to share research, case studies and practical applications to visualize educational possibilities that support the innovation of learning environments and the mobilization of open educational practices. Another objective was the development of digital, didactic, and technological skills as well as the participants' research, communication, innovation, and entrepreneurship skills.

Activities The workshop consisted of an interactive innovation event with ROADMAP dynamics, based on practical activities, networking and knowledge exchange, with an open space for analysis and co-construction among speakers, specialists, and participants (Stacey, 2018). The workshop was linked to the International Congress on Educational Innovation activities, which was an opportunity for improvement and added value. During the workshop, speakers and specialists who shared research, case

Table 1 Cases studies on open education in Latin America

Project	Objectives	Participants	Methodology	Final products
UNESCO international chair 2019 open educational movement 	Build international networks for innovative projects with social impact within the framework of the UNESCO 2019 international stay through active methodologies and interactions with innovation, education, and research experts to provide creative solutions to contribute to the Sustainable Development Goals (SDGs) of the UNESCO 2030 agenda	70 academics from 11 countries (Chile, Colombia, Costa Rica, Ecuador, Peru, Spain, United States, England, Mexico, Nicaragua, and the Dominican Republic)	Roadmap strategy (coordinated by Open Education Global), collaborative work, project-based learning, and videos with mobile devices	14 projects and videos designed collaboratively by teams from international networks
UNESCO international chair 2021 open educational movement 	Build international networks for innovative projects with social impact within the framework of the UNESCO 2021 international stay through active methodologies and interactions with innovation, education, and research experts to provide creative solutions to contribute to the Sustainable Development Goals (SDGs) of the UNESCO 2030 agenda	77 academics from 11 countries (Mexico, Peru, Ecuador, Chile, Colombia, Spain, United States, Guatemala, Costa Rica, the Dominican Republic, and Argentina)	The Architecture of Horizons strategy, collaborative work, project-based learning, and videos	21 projects and videos designed collaboratively by international network teams

Table 2 Characteristics of the participants of the UNESCO 2019 international stay

Country/Role	Professor	PhD candidate	Researcher	Educational administrator	Graduate student	Instructor	Total
Mexico	11	8	6	6	0	1	32
Peru	4	0	1	3	4	0	12
Chile	2	0	1	0	3	0	6
Colombia	2	2	0	0	1	1	6
Ecuador	3	0	0	0	0	0	3
Dominican Republic	0	3	0	0	0	0	3
Argentina	1	0	1	0	0	0	2
Costa Rica	0	0	1	0	0	1	2
Spain	0	0	0	1	0	1	2
Nicaragua	1	0	0	0	0	0	1
U. S. A	0	1	0	0	0	0	1
Total	24	14	10	10	8	4	70

studies and practical applications of open education carried out various activities such as attending conferences, preparing oral presentations, and participating in a collaborative project.

Methodology The methodology was based on the roadmap dynamics. The participants received a Roadmap Creation Toolkit with materials to document and color code the open education initiatives, open assets, people and community, operations and sustainability, and benefits and value propositions. Each roadmap included a description of open education. On the first day, participants created their personal roadmap documenting their open education initiatives. On the second day, participants developed collaborative roadmaps that combined different open education initiatives to form a larger initiative in partnership with others. In the following days, participants continued working on their initiative until the end of the workshop.

Final projects At the end of the workshop, participants presented a final document and a video with complete details of their collaborative open education initiative. In total, 14 final projects were presented by the 70 academics participating in the 2019 edition of the workshop. The techno-pedagogical components of the products designed by the participants to encourage the open educational movement included digital platforms ($n=4$), MOOCs ($n=5$), online courses ($n=1$), open access publications ($n=1$), social media ($n=1$), webpages ($n=1$), and workshops ($n=1$). See Fig. 2.

The presented initiatives designed by the participants proposed activities categorized as production ($n=8$), dissemination ($n=3$) and mobilization ($n=3$) practices of the open educational movement. See Fig. 3.

The production classification was given to a project designed by 6 academics involving the creation of OER for teacher training in digital skills (T9). Another example of production practices was given to the teams creating a MOOC for Continuing Education of Health professionals (T12). The dissemination classification was given in a project that compiled and made available to schools and educational entities a repository of open-access virtual learning objects with an application guide that could be used to promote

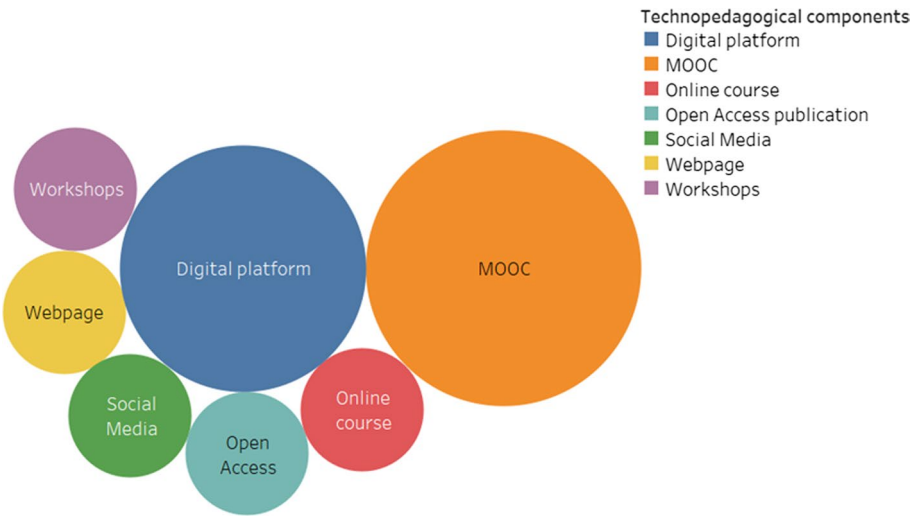

Fig. 2 Technological components of 2019 open educational initiatives

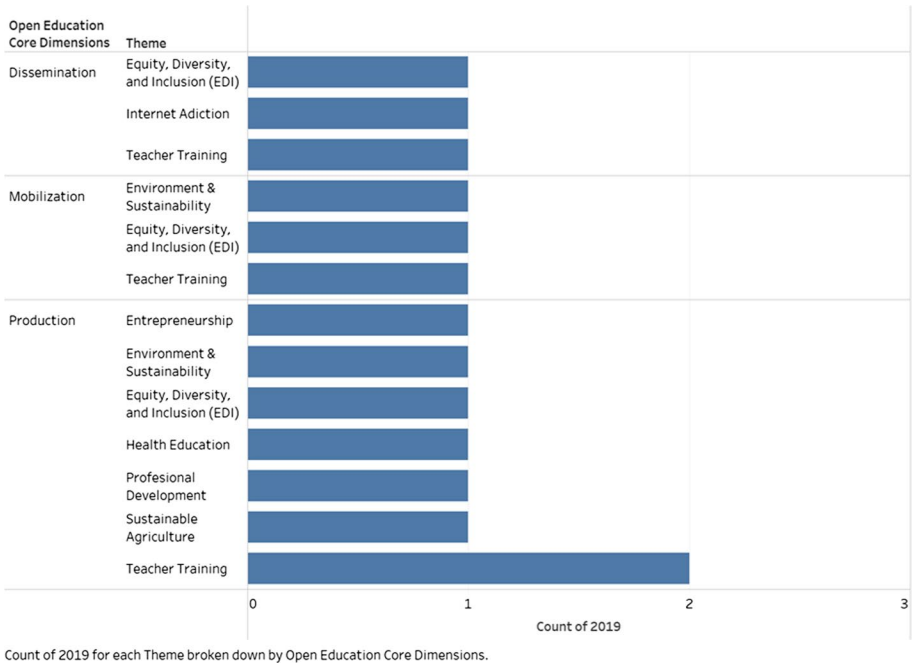

Fig. 3 Open educational practice per themes (2019)

gender equality for boys and girls in Latin America (T6). A project classified as mobilization involved facilitating workshops as part of a teacher training initiative (T8). None of the projects designed by the participants was assigned to the *use* classification. A summary of the projects and initiatives can be accessed in the work of Ramirez-Montoya (2019).

The case of the 2021 UNESCO chair for open educational movement in Latin America workshop

The international workshop was held from September 29 to December 17, 2021, and was divided into two phases (Ramirez-Montoya, 2021). During the first phase, from September 29 to November 24, a series of weekly webinars, "Open and Inclusive Education," were available for participants. Subsequently, from December 6 to 17, 2021, the activities were held at the Tecnologico de Monterrey (Campus Monterrey, Mexico). The topics addressed during the workshop included sustainable development goals; open and inclusive education; building capacity in stakeholders to create, access, reuse, adapt, and redistribute OER; development of supportive policies; promotion of effective, inclusive and equitable access to quality OER; promotion of sustainability models for OER; promotion and strengthening of international cooperation; fostering the creation of sustainability models for OER; and promoting and strengthening international cooperation.

Participants 77 academics from 11 countries (Mexico, Peru, Ecuador, Chile, Colombia, Spain, Argentina, the United States, the Dominican Republic, Guatemala, and Costa Rica) participated in the UNESCO 2021 international stay of the Open Educational Movement for Latin America. Table 3 presents the roles of participants per country of origin.

Table 3 Characteristics of the participants of the UNESCO 2021 international stay

Country/Role	Professor	PhD candidate	Researcher	Educational administrator	Graduate student	Instructor	Total
Mexico	9	8	5	4	0	9	35
Peru	3	1	0	2	3	3	12
Ecuador	3	2	0	1	1	3	10
Chile	0	2	1	2	0	1	6
Colombia	1	1	2	2	0	0	6
Spain	1	1	0	0	1	0	3
Argentina	0	0	0	1	0	0	1
U. S. A	0	0	1	0	0	0	1
Dominican Republic	0	0	0	1	0	0	1
Guatemala	0	0	0	0	0	1	1
Costa Rica	0	0	0	0	0	1	1
Total	17	15	9	13	5	18	77

Objectives The main objective of the workshop was to analyze components and practices of the open education movement, with particular attention to UNESCO's recommendations for open education, through a series of webinars and an international workshop with speakers and specialists to share research, case studies and practical applications, to project educational ventures that support innovation and the mobilization of open educational practices.

Activities The workshop consisted of an interactive innovation event with the Horizons Architecture innovation methodology, based on webinars, practical activities, networking and knowledge exchange, with an open space for analysis and joint construction among speakers, specialists and participants. The workshop was linked to a series of weekly webinars and activities of the International Congress on Educational Innovation, which resulted in an opportunity for improvement and added value for participants.

Methodology The Horizons Architecture innovation methodology is an adaptive model to qualitatively and quantitatively assist the capacity to generate strategies (decision making), public undertakings, and future scenarios in complex systems with high certainty, within a specific period (Barroso et al., 2019). This methodology was implemented during the workshop for participants to propose open education initiatives and solutions collaboratively.

Final projects At the end of the 2021 edition of the workshop, participants presented a final document and a video providing complete details of their collaborative open education initiative. In total, 21 final projects were presented by the 77 academics participating in the workshop activities. The techno-pedagogical components of the products designed by the participants to encourage the open educational movement included digital platforms ($n=7$), webpages ($n=2$), MOOCs ($n=2$), augmented reality ($n=2$), 4.0 technologies ($n=2$), virtual reality ($n=1$), Podcasts ($n=1$), Learning Management Systems or LMS ($n=1$), emerging technologies ($n=1$), and collaborative online tools ($n=1$). See Fig. 4.

The presented initiatives designed by the academics participating in the workshop proposed activities categorized as production ($n=11$), dissemination ($n=4$) and mobilization ($n=6$) practices of the open educational movement. See Fig. 5.

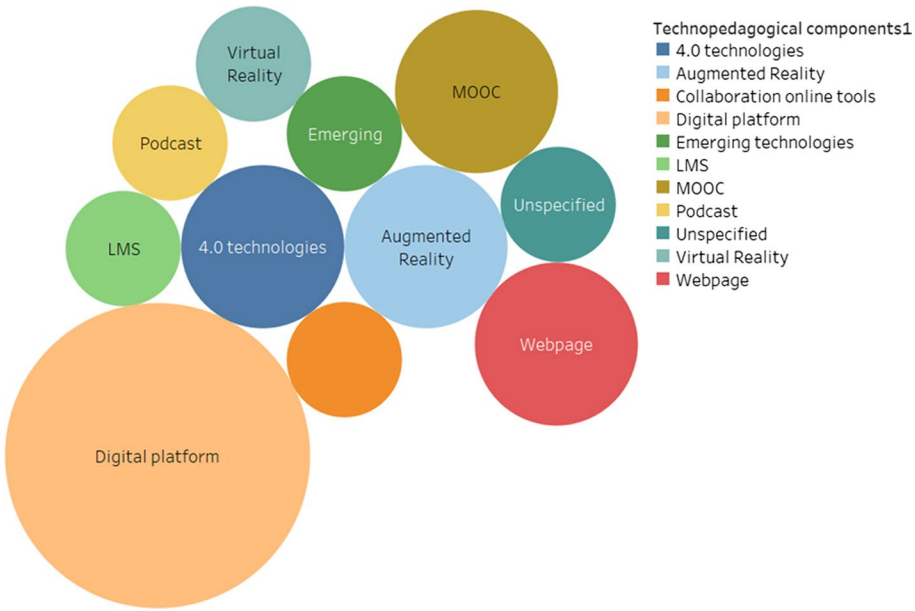

Fig. 4 Technological components of 2021 open educational initiatives

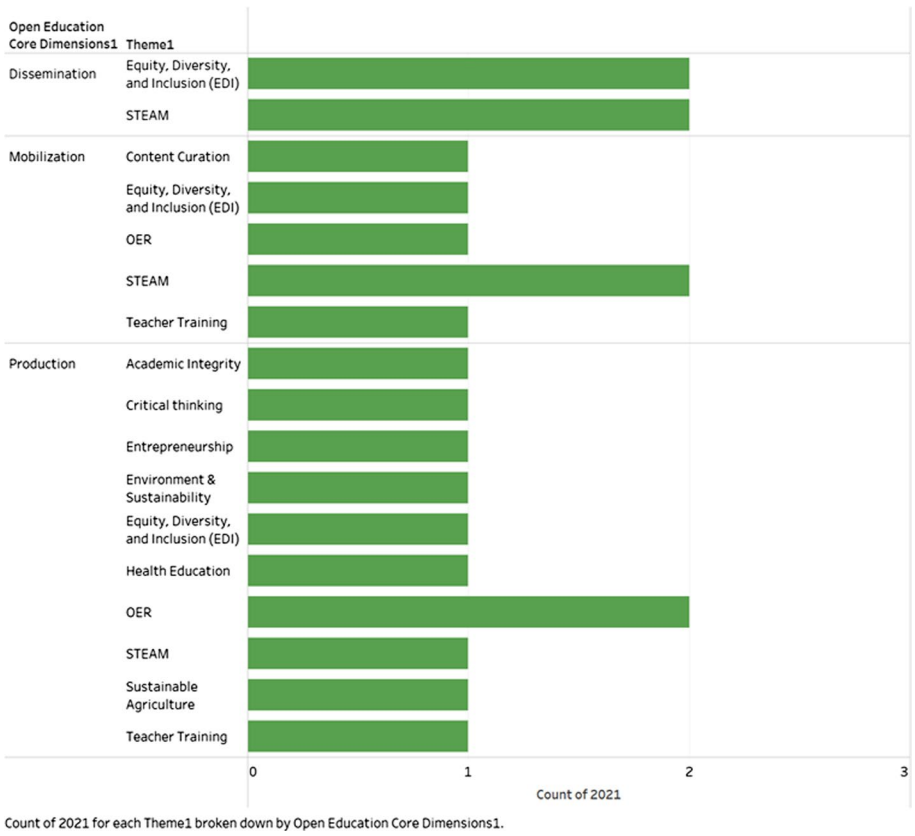

Fig. 5 Open educational practice per themes (2021)

Some examples of the production classification were given to a team of academics who designed and created a microMOOC on critical thinking for high school students through the international collaboration of professionals (T4) and to academics who proposed the creation of AlimentarC+. This OER allows professionals, university students, and the community, in general, to find and share information associated with productive models of the sustainable economy (T13). The dissemination classification was given in a project involving OER and citizen science projects available in a repository to reduce the gender gap in the Latin American scientific community through the dissemination of scientific production carried out mainly by women (T20). Mobilization was the classification in a project that involved categorizing Augmented Reality OER that help to stimulate creativity and interest in STEAM sciences through open practices by high school students (T1). None of the final projects was categorized as *use* of OER. A summary of the projects and initiatives can be accessed in the work of Ramirez-Montoya (2021).

Discussion

The use of emerging and 4.0 technologies in initiatives of the open education movement continues to increase. According to the first research question, as shown in Figs. 2 and 4, a more significant number of technological components based on emerging technologies such as virtual reality and augmented reality were documented in the workshop conducted in 2021 compared to those identified in the 2019 workshop. As pointed out by Zhou et al. (2020), Lane (2017), Ahel and Lingenau (2020) practitioners and researchers continuously seek strategies based on technological innovation to ensure their integration into academic and professional development and in OER to increase access and boost open education. Technological advances can enable new avenues of use, production, dissemination, and mobilization of open resources (Tlili et al., 2021). For instance, Tlili et al. (2021) identified emerging technologies applications in OER, such as the use of artificial intelligence and blockchain for searching, mapping, and locating OER, which provides new opportunities for using and disseminating OER.

The open education movement has promoted chiefly the practice of producing OER. Regarding the second research question, as shown in Figs. 3 and 5, the preponderance of production puts it on the first level in both workshop editions, followed by dissemination and mobilization. This is somewhat related to the findings reported by Ramirez-Montoya (2020), who analyzed the scientific literature on open education and concluded that there is a challenge to promote mobilization practices that might impact other learning contexts since production and dissemination were the most frequent categories in her analysis. Also, the lack of projects focusing on using OER that stands out in Figs. 3, 5, and 6 could be explained by the fact that academics collaborated to mobilize open education initiatives as stated in the workshop's objectives. In the future, special attention must be paid to training initiatives to include objectives related to the four identified open education practices (i.e. use, production, dissemination, and mobilization).

Inclusive access to education and continuing professional development is a constant concern in open education initiatives. Figures 3 and 5 present the open educational practices per the theme of each workshop. In those figures, *equity, diversity, and inclusion* and *Teacher training* were themes of interest for the academics participating in both events. As Rodríguez-Abitia et al. (2020) and Zhou et al. (2020) stated, Higher Education

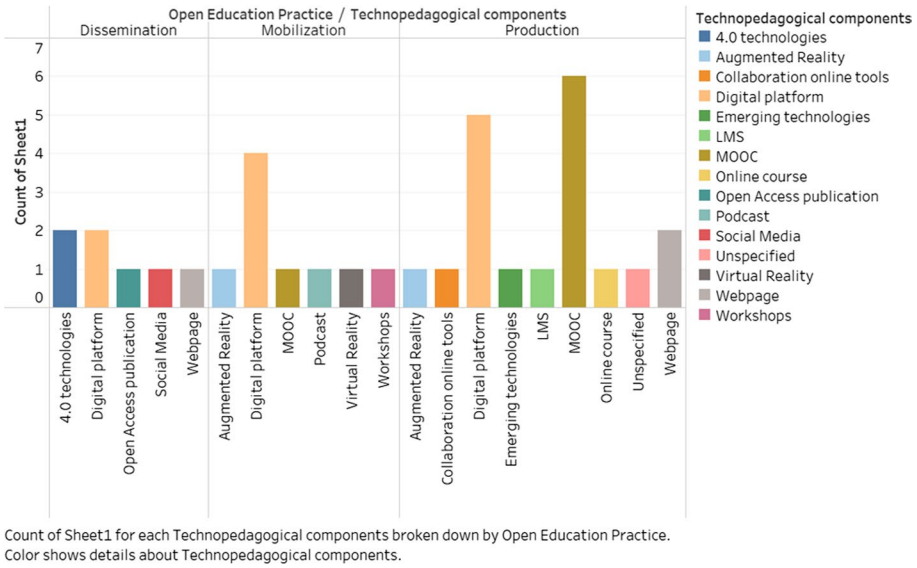

Fig. 6 Summary of technological components broken down by open education practice

Institutions play an essential role in implementing open education initiatives and solutions related to Sustainable Development Goals. Since participants of the 2019 and 2021 events were academics from different Higher Education Institutions, their backgrounds might have influenced the theme selection. Plus, open education has always been associated with practices, resources, and open-access technologies that involve the production, use, dissemination, and mobilization of training (Ramirez-Montoya, 2020). According to our findings, training initiatives addressed to teachers' and instructors' development are not the exception. Open Education initiatives are directly associated with UNESCO's Sustainable Development Goals.

Play2Train4C: an intervention proposal

Play2Train4C is a new game-based intervention proposal based on the results of the previous workshops that aims to support academics in designing teaching and learning activities for complex thinking skill training in university students. Play2Train4C stands for Playful interactions to train for complexity: Play2 refers to the two types of methodologies (Lean Launchpad and Hexa-GBL) and Train4C to the four sub-competences of reasoning for complexity (scientific, systemic, critical, and innovative thinking). This intervention proposal relies on active learning and digital game-based learning as a theoretical framework underpinning the proposed instructional activities. It is an example of open education practice mobilization and will be implemented during the 2023 edition of the international workshop on open education. In this proposal, the study of the initiatives developed during the international open education workshop of previous years (2019 and 2021) has been considered. See Fig. 7.

Methodology It is based on the Lean Launchpad methodology or Lean Startup Method (Blank, 2013) and the HEXA-GBL methodology (Romero, 2015). On the one hand, the Lean LaunchPad approach extends the process of validating business model hypotheses until a startup finds one that is repeatable and scalable by providing tools for testing

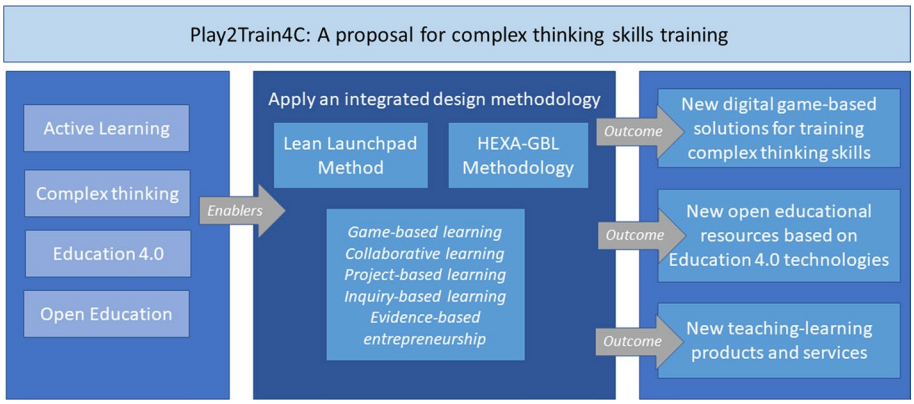

Fig. 7 The Play2Train4C proposal

hypotheses and enhancing the venture through experimentation and iteration. This fast launch methodology will be adapted to the context of open education to assist academics in launching open education initiatives. On the other hand, the HEXA-GBL methodology is a six-phase methodology for designing and assessing GBL activities from a learner-centered perspective. This step-by-step methodology aims to facilitate decision-making concerning game-based activities and modalities that better fit the learners' needs in their specific contexts. The steps include (1) defining learning objectives, (2) performing a learner-centered need analysis, (3) selecting game modalities, (4) analyzing the impact of the game in terms of learning and feedback, and (6) assessing the gaming and learning experience. The HEXA-GBL methodology will also be implemented to accompany academics in designing game-based solutions with the potential to train students in complex thinking skills.

Activities A real-world immersive experience in collaborative game design for complex thinking skills training will be proposed to academics participating in the 2023 edition of the workshop. A series of lectures, talks with specialists, and collaborative, hands-on sessions for project development is on the agenda.

Theoretical Foundations Active learning pedagogies such as digital game-based learning and collaborative-, project- and inquiry-based learning underpin the envisaged instructional strategies.

Resources As for the instruments and tools available for the participants, diverse pedagogical materials, access to education 4.0 technologies, and guidelines for game design will be provided to the members of each team to guide them in designing the core game elements that must be considered when creating a game-based intervention.

Conclusion

This study was carried out to promote the reflection and analysis of experiences on open education initiatives among practitioners and researchers in the educational field during international open education workshops. The topic is justified to the extent that the use and production of repositories that act as OER catalog sources, the dissemination of practices in academic, governmental, and institutional environments, and the mobilization of educational practices positively impact access to quality education, which is directly related to the sustainable development objectives proposed by UNESCO.

The techno-pedagogical components of the products designed by the participants to encourage the open educational movement include were enabled by digital platforms, MOOCs, online courses, open access publications, social media, webpages, workshops, augmented reality, 4.0 technologies, virtual reality, podcasts, Learning Management Systems, emerging technologies, and collaborative online tools (See Fig. 7). The open educational movement practices identified in the final products designed by the participants are production, dissemination, and mobilization of OER.

The findings of this study reveal that (A) the use of emerging and 4.0 technologies in initiatives of the open education movement continue to increase; (B) most of the open education initiatives designed by academics participating in the workshops were focused on the production of OER; and (C) inclusive access to education and continuing professional development of teachers is a constant concern addressed in open education initiatives. The results of this research are of interest to trainers, academics, researchers, and decision-makers interested in open education. Training and development interventions involving the creation or design of open education initiatives should focus on promoting all types of open education practices (i.e., use, production, dissemination, and mobilization).

The study identifies some limitations for consideration. For example, the findings of this study reflect the reality of the Latin American academics participating in the study's international workshops and cannot be generalized due to the qualitative nature of the study. However, similar studies can be replicated in different contexts to understand the realities of the open education movement in other regions. Future studies might focus on analyzing the practice of the open educational movement executed in specific smart learning environments and examining the impact of open education initiatives depending of the smart learning environments. Also, further research might be needed to analyze the evolution of the open education initiatives presented by academics longitudinally. Evaluating the evolution of such initiatives in time might provide insights into the best practices that might benefit the design of OER and open education initiatives.

Abbreviations

GBL	Game-based learning
HEXA-GBL	A six steps methodology for GBL design and evaluation
UNESCO	United Nations educational, scientific, and cultural organization
OER	Open educational resources

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Author contributions

All authors contributed to the study conception, design, data collection and writing of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors have no competing interests to declare that are relevant to the content of this article.

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