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3D open educational resources and emergent pedagogy in university training in health sciences. The affordances and pedagogies of creativity

Los recursos educativos abiertos 3D y la pedagogía emergente en la formación universitaria en ciencias de la salud. Las affordances y las pedagogías de la creatividad

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ABSTRACT

Introduction: UNESCO defines Open Educational Resources (OER) as freely accessible and adaptable educational materials, whose integration in education, especially in post-pandemic times and in the digital era, has been limited, despite the efforts of institutions such as the Facultad de Estudios Superiores Zaragoza to promote their use in hybrid and flexible teaching modalities. This study analyzes the transformation of higher education in the context of the COVID-19 pandemic, focusing on the integration and impact of Open Educational Resources (OER) and Information and Communication Technologies (ICT).
Methods: a literature review and analysis of current educational practices in universities was conducted, with special attention to the adoption of OER and the use of hybrid and digital teaching methodologies.
Results: the results indicate that, despite the accessibility and adaptability of OER, their adoption in university education has not been extensive, mainly attributed to lack of knowledge about their use and potential. The pandemic has accelerated the need to adapt pedagogical strategies, highlighting the importance of interaction and collaboration in learning. Maker pedagogy and 3D printing are identified as valuable tools to improve understanding and practical skills, especially in the health sciences.
Conclusion: the study concludes that post-pandemic education requires an adaptive, interactive and technologically integrated approach, promoting continuous learning and adaptation to changing cultural and cognitive practices. It underscores the need to democratize design and manufacturing technologies and to foster collaborative and participatory learning communities through OER.

Keywords: Open Educational Resources; Information And Communication Technologies; Maker Pedagogy; Hybrid Teaching; 3D Printing.

RESUMEN

Introducción: la UNESCO define los Recursos Educativos Abiertos (REA) como materiales educativos de libre acceso y adaptables, cuya integración en la educación, especialmente en tiempos post-pandemia y en la era digital, ha sido limitada, a pesar de los esfuerzos de instituciones como la Facultad de Estudios Superiores Zaragoza para promover su uso en modalidades de enseñanza híbridas y flexibles. Este estudio analiza la transformación de la educación superior en el contexto de la pandemia de COVID-19, enfocándose en la integración y el impacto de los Recursos Educativos Abiertos (REA) y las Tecnologías de la Información y la Comunicación (TIC).
Métodos: se realizó una revisión de la literatura y un análisis de las prácticas educativas actuales en universidades, con especial atención a la adopción de REA y el uso de metodologías de enseñanza híbridas y digitales.
Resultados: los resultados indican que, a pesar de la accesibilidad y adaptabilidad de los REA, su adopción

en la educación universitaria no ha sido extensa, atribuyéndose principalmente al desconocimiento sobre su uso y potencial. La pandemia ha acelerado la necesidad de adaptar las estrategias pedagógicas, destacando la importancia de la interacción y colaboración en el aprendizaje. La pedagogía maker y la impresión 3D se identifican como herramientas valiosas para mejorar la comprensión y las habilidades prácticas, especialmente en las ciencias de la salud.

Conclusión: el estudio concluye que la educación post-pandemia requiere un enfoque adaptativo, interactivo y tecnológicamente integrado, promoviendo un aprendizaje continuo y una adaptación a prácticas culturales y cognitivas cambiantes. Se subraya la necesidad de democratizar las tecnologías de diseño y fabricación y de fomentar comunidades de aprendizaje colaborativas y participativas a través de los REA.

Palabras clave: Recursos Educativos Abiertos; Tecnologías De La Información Y La Comunicación; Pedagogía Maker; Enseñanza Híbrida; Impresión 3D.

INTRODUCTION

The UNESCO coined the term Open Educational Resource (OER) to describe freely accessible educational materials used for teaching, learning, or research. These resources are either in the public domain or are published under an intellectual property license allowing their free utilization, adaptation, and distribution.[1]

In the early 21st century, especially in the post-COVID-19 pandemic era, we are witnessing the continuation of a trend that began in the late 20th century regarding the integration of Information and Communication Technologies (ICT) into daily life. These technologies are transforming people's lives by serving as facilitators in an interconnected world through digital networks. These networks enable a level of trust in these powerful tools for transmitting information digitally.

During the past three years, amidst confinement situations where educational institutions conducted activities using the Emergency Remote Teaching (ERT) model, until the current year (2023), it has been observed that the integration of OER in various educational activities has not been a prevailing educational practice. There is still a lack of awareness within the university community regarding OER.[2] This is mentioned because of the unique qualities of OER, enabling the free use and dissemination of digital learning resources without copyright restrictions. This becomes particularly valuable when regular circumstances hinder or make it impossible to access educational institutions, libraries, or academic information centers.[3]

The Facultad de Estudios Superiores Zaragoza (FES Zaragoza) at the Universidad Nacional Autónoma de México, like other higher education institutions, has undergone adaptations to meet the demands of new learning conditions. The author of this document serves as a coordinator for two academic networks: RED RITUAL, focused on Technology-Mediated Learning, and RED IDEA, dedicated to innovating and researching learning processes. Members of these Ibero-American networks have welcomed these adaptations, emphasizing the promotion and development of activities in a hybrid learning model. They aim to encourage the use and adoption of digital resources for learning and to foster pedagogical flexibility. In this context, there is a desire to promote pedagogical self-management through the creation of 3D OER.

DEVELOPMENT

Background

The COVID-19 pandemic presented a major challenge in maintaining education across all levels without physical presence. As we resume face-to-face activities, the health impacts on our learners due to the pandemic's consequences remain evident. Whether it's the Post-COVID Syndrome or emotional distress resulting from prolonged confinement and remote work, the primary effects include insomnia, anxiety, decreased lung capacity, and in certain instances, impairment of short and medium-term memory.[4]

The recent experience of the COVID-19 pandemic serves as a reminder that the pedagogical design in higher education needs to consider that distance education, supported by the Internet, shouldn't solely involve placing educational materials on a webpage for distribution.[5] The challenge posed by these emerging digital learning environments is to prevent the replication of the mistakes and drawbacks commonly seen in traditional face-to-face education. Acknowledging that new virtual learning spaces demand innovative approaches to learning resources, it's essential not to mimic unfavorable practices from face-to-face education, such as directly duplicating documents through photocopying. Incorporating learning resources goes beyond merely transferring decontextualized digital documents; it now occurs at a significantly faster pace, facilitated by the speed and extensive coverage of digital networks.[6]

In the post-pandemic era, both traditional face-to-face education and the emerging hybrid mode establish physical and virtual spaces for communication. These spaces facilitate the exchange of information and,

depending on their usage, enable the development of a teaching-learning environment aimed at promoting collaboration between educators and students. This occurs within a dynamic interaction framework, employing culturally selected content materialized through representation using the various languages supported by technological media.[7,8,9] In these environments, both the sociocultural and discursive aspects of interaction hold particular significance, along with the design of resources serving as suitable and relevant mediators for learning, such as OER.

Recent experiences in the return to face-to-face classes highlight the necessity of supporting our learners in various aspects. This includes promoting collaborative work, addressing cognitive challenges like memory difficulties, attention issues, and executive function limitations, as well as enhancing reflective reading and encouraging active participation. Moreover, reinforcing connections with prior knowledge is essential. Simultaneously, the link between communication and education emerges as a pivotal field in light of this recent experience. This evolution relies on integrating new methods that merge face-to-face activities with digital resource support, such as designing and developing OER within technologically and pedagogically open environments. This transition aims to progress towards a more equal and fairer university education, whether face-to-face or hybrid, fostering the establishment of an inclusive and equitable learning atmosphere.

Although there was an increase in the use of ICT and CAT (Computer-Assisted Teaching) during the confinement, the return to face-to-face activities has revealed the necessity for guidance in technology-mediated learning. This guidance aims to help students shift from being consumers to creators of OER, particularly to support hybrid learning and the integration of mobile devices like tablets and smartphones. Addressing the issue through emerging pedagogy and the design of OER.

It's essential to analyze and contemplate educational practices through novel pedagogical approaches. These approaches should allow for the examination of educational issues by adopting new ways of perceiving reality. This includes recognizing the intricacy of educational problems and understanding the characteristics and circumstances of social actors, educators, and learners amidst diverse civilizational crises.

Rather than initiating a debate regarding pedagogy, it's interesting to revisit certain elements, like the one Davies presents, highlighting the explicit connection between the social context and educational practice. "Pedagogy involves a viewpoint (theory, a set of beliefs) about society, human nature, knowledge, and production concerning educational objectives. It also encompasses the incorporation of specific terms and guidelines regarding the political and practical methods for its achievement."[10]

We agree with Rovai's viewpoint concerning the consensus that quality learning relies significantly on interaction. However, this aspect has been predominantly addressed from what he labels as "technological perspectives," lacking a solid pedagogical or psychopedagogical theoretical basis. He considers essential to precisely analyze the role of interactive modalities in the learning process, whether in traditional face-to-face teaching or in open and distance education.[11]

Similarly, this writing intends to explore the new demands placed on educators and learners when engaging in this innovative educational approach. It also delves into the new challenges faced by emerging pedagogy. While citing Lucio Teles' insights regarding the integration of digital resources and Internet support in teaching, we ask ourselves: "Is this truly a new paradigm, or merely old wine in new wineskin?"

Towards a new learning culture with 3D OER

We require a fresh learning culture that fosters creativity and nurtures imagination to adapt to an ever-evolving world.[12] Emerging pedagogies are surfacing within virtual learning settings during times of significant uncertainty. They support individuals' educational processes primarily by promoting continuous learning through technology and OER.[13]

When designing educational activities to encourage the use of OER in individual and group work, adhering to the principles of Emerging Pedagogy, learning is fostered through methodologies such as Design Thinking. This approach considers empathy as the starting point in the design process for innovation.[14] In the field of health sciences, the Maker pedagogy as an emerging educational approach, combined with 3D printing, can be an effective combination to improve learning and the development of clinical skills. The use of 3D printing allows for the development of precise and realistic models representing anatomical structures and medical procedures. This technology proves to be valuable in comprehending and practicing clinical concepts and skills (Figure 1).

Figure 1. 3D printing of a human skull for teaching purposes in health sciences. Image from own project PAPIIT, 3D design and the Maker community

It is essential to comprehend cognitive changes and the influence of cultural practices to tailor our teaching methods. This stands as a central aspect in the pedagogical design of OER and in the development of educational activities that encourage their integration in both individual and group work. This approach arises from learners facing significant clinical practice issues that need the application of knowledge from fundamental areas.

Active methodologies are key in the significant mission of education. Design thinking contributes to problem-solving, while the Maker movement collaborates as part of this approach. These methods should not be limited to using digital tools to continue teaching learners in the same conventional manner. By integrating the Design Thinking approach, the goal is to address the new needs of learners, fostering learning and empowerment, participation, and collaboration within students' learning environments and networks.

Nowadays, thanks to various technologies linked to the three digital revolutions it is possible to create educational content through Computer-Aided Design (CAD). This content can then be manufactured using 3D technologies or Computer-Aided Manufacturing (CAM). The most remarkable aspects of recent digital revolution is the rapid accessibility to 3D design and printing technologies. This transformation is fundamentally changing manufacturing practices from extraction-based methods to additive approaches. Concurrently, the landscape of design and production spaces is evolving from localized setups to distributed models.[15]

Apart from other increasingly used technological tools in teaching and learning processes, augmented reality arises as a technology that overlays computer-generated images, 3D models, or other types of information onto a real-world image obtained through a screen. A 3D model refers to a mathematical depiction of any three-dimensional object, whether it's animate or inanimate, created by a specialized software.

These 3D virtual environments have the capability to simulate three-dimensional physical spaces, whether they are real or not. Within these scenarios, users can be fully immersed, experiencing the feeling of being present in a simulated environment that seems real to them. Currently, thanks to the development of 3D printing, computers have the potential to reproduce products directly from digital files. This phenomenon is part of what's known as the "democratization of design and manufacturing tools," establishing the "Maker Movement" as one of its most interesting cultural manifestations, advocating for the motto of "do it yourself."[16]

The design of 3D OER and affordances

The concept of "affordances" comes from ecological psychology, and it refers to the potential action opportunities provided by an environment. "Affordance" refers to the relationship between the properties of a physical object and an individual, and how the individual perceives the object's potential for use during a specific activity.[17] Examples of affordances may include a doorknob specifically designed in a way that "invites" the individual to perform the action of opening a door. Other examples may include vehicle handles or a cup. The concept of affordances has been adopted by designers to create products that facilitate intuitive use and action. Affordances are opportunities for action (Figure 2).

Figure 2. Incorporating affordances for object design. Dwivedi, 2017.[18]

Cognitive affordances

A cognitive affordance relates to an activity theory based on the actions taken by an individual to achieve a purpose, involving other actions organized hierarchically in steps or processes. A cognitive affordance encompasses design features that help users in their cognitive actions, like reasoning or knowing specific aspects of an object, and the consequences resulting from its activation.

A question arising when contemplating cognitive affordances is: Does the object's design include clear and understandable signals about how to use it and the expected outcome? To illustrate this aspect of cognitive affordance, let's consider the design of communication interfaces, like WhatsApp. This application integrates symbols, visual metaphors, and commonly used design conventions in apps. For instance, an icon resembling a paper clip implies the ability to attach items once it´s activated, while an empty box with a cursor suggests the option to input text, and so on.

These are aspects that users have learned over years of using interfaces. In the case of the "Send" button, the white triangle resembles the "Play" action, while also functioning as a metaphor for a paper airplane, implying that the written content can be sent to a recipient (Figure 3).
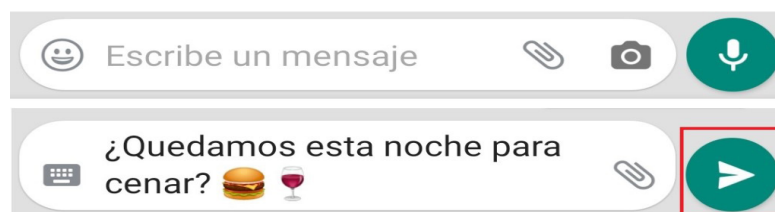

Figure 3. WhatsApp interface. Koshechkin, 2021.[19]

Cognitive affordance, artifact, and mediated action in the maker community

Interactions among individuals from diverse social or cultural backgrounds involve engaging in academic activities that build meanings through a shared, negotiated communication code. This occurs notably through the realization of activities, such as OER-mediated activity, transforming dialogue and interaction process into representations of oral language, which is the conventional human way of establishing relationships in everyday life. For instance, when participating in collaborative activities to collectively build objects within a maker or resource-makers community.

Consequently, ICT-OER serve as fundamental pillars for fostering both physical and virtual maker communities. These communities are progressively integrating into academic and everyday life within educational institutions. Individuals from diverse social classes and ideological backgrounds are increasingly gathering in these physical and virtual spaces, potentially seeking aspects that traditional communities no longer offer, possibly due to these conventional communities being in crisis and, in many instances, undergoing significant dissolution. Some technologies can amplify knowledge construction through various collaborative exchanges: among students, students and educators, colleagues, educators and specialists, and students and specialists. All participants share a mutual interest in collaborating, and co-creating knowledge.

If applied to our 3D OER case, Crovi´s appropriation process refers to the challenge of explaining the term "appropriation" in terms of integrating these elements into both individual and collective activities. This emphasizes its crucial role in the current social context, giving significance to the cultural practices of individuals who have predominantly incorporated ICT-OER and/or EdTech into their daily routines.[20]

Crovi takes Vygostky and Leontiev as the leading authorities to explain the process of appropriation, and reveals this concept by focusing on internalization. This concept depicts the transformation of the inner self,

leading to a fresh interaction with cultural products. As these products multiply, they function as external aids in psychological processes, encompassing diverse traits: containing semiotic systems, structures, concepts, techniques, and more, which we can internalize, thereby culminating in appropriation.[20,21] As these products become rooted in individuals, they evolve into personal and private tools. Simultaneously, they serve as vital elements for the development and preservation of society and culture by fostering socio-cultural interaction. [22] Likewise, the activity theory advocates for the social nature of individuals, who serve as active agents of appropriation. In this theory, Leontiev argues that human processes can be observed at three levels:

- The highest and broadest level is characterized by the activities and motivations that guide it.
- Intermediate level includes the associated actions and goals.
- At the lowest level, the operations performed by individuals to attain the higher-level objectives are analyzed.

These elements interact dynamically and can change according to conditions. From the viewpoint of the activity theory, as proposed by Crovi, Leontiev recognizes the mediating function of tools or artifacts, such as 3D OER. Additionally, he emphasizes that these tools are either created or modified as a consequence of activity, occurring within a distinct cultural context.[23] Crovi applies these ideas to analyze the dynamics of innovation in the digital technological field and the users' influence on its transformation. Participating elements include subject, object, actions, and operations.

Thus, subject and object guide actions, whereas operations are automatic actions or routines developed through practice and repetition.

This section reflects on Crovi's work and that of other authors contributing to understanding the concept of ICT-OER appropriation and its correlation with society and culture in both formal and informal learning environments.[20]

When making an analogy between these ideas and 3D OER the learning processes of individuals as they utilize these resources can be observed. This includes considering their ability to generate new uses and potentially transform the tools. The ongoing innovation of these tools requires individuals to engage in continuous learning, posing a challenge for adults, termed by Crovi as "additional knowledge." The term "additional knowledge" is used to describe the process through which adults acquire new skills and knowledge required for the development of their profession or trade. This process involves training and ongoing updates, which must consistently align with the innovation of OER for learning, as well as the technologies considered for their design and production. [20,21,23]

Cognitive affordances and the appropriation process

In a literal sense, appropriation is defined as taking a tangible or intangible object and making it one's own.[20,21,23] In this context, Crovi conducted an extensive study on the appropriation of ICT, which we have revisited for the analysis of the appropriation process of 3D OER within the higher education environment.[24] Crovi argues that appropriation doesn't solely involve the subject taking an object and claiming ownership. Appropriation implies a thorough understanding and use of the capacities and functionalities of the object being appropriated, i.e. the individual appropriating an object must possess the necessary skills to use it effectively and consider it "so crucial for his/her daily activities [...] that it becomes an integral part of his/her social practices." [20] Therefore, according to Crovi, appropriation represents a condition where an individual possesses all the necessary skills to use ICT in his/her life, encompassing academic life as well.[24]

Thus, these symbolic devices are associated with cognitive affordances and the skills humans develop to use them. This process appears to each individual as a personal challenge to solve, involving the individual's appropriation of technological objects and the set of cultural and motivational circumstances that surround him/her in society. Appropriation is an individual and simultaneously social process where the subject's motivation and creativity are present and assimilated uniquely, yet within a common framework of specific practices. These practices, as previously discussed, can be modified and even surpass the expectations surrounding the use of the object. In contrast to the creative and innovative practices that individuals can pursue with technological objects, there are also individuals who follow familiar paths and are either unable or unwilling to explore new possibilities. This could be due to a lack of access or personal conviction. It's important to recognize that different abilities exist when it comes to appropriating 3D OER, and these abilities can be influenced by various factors. Economic disparities are particularly significant. Individuals in a society lacking basic welfare resources will likely have limited opportunities to appropriate resources designed and produced with ICT-OER, as well as the social practices associated with them.

Disparities in the appropriation of ICT-OER are contingent upon the speed of technological changes. Despite individuals in societies living within the same time frame, this period fractures due to the fast advancements in technology. Proulx (cited by Crovi) highlights that a crucial aspect for the social adoption of ICT is the implementation of public policies and the active involvement of users in innovation processes.[20] In general, public policies focus on establishing a robust market for technological tools but tend to overlook the social needs. Similarly, companies involved in the adoption of these tools employ marketing strategies that, rather than

pursuing social benefit, prioritize their economic interests. Hence, the significance of technological products is created from the social and cultural practices individuals associate with them through their use and subsequent ownership. Power doesn't inherently reside within the technologies; it is instead socially constructed.[25]

The emergence of new digital and 3D printing resources presents new prospects for collaborative work, whether face-to-face or remotely. These aspects have been used in the context of online education in the post-COVID-19 era. It's crucial to address the need for keeping the involvement of students who require more than mere text-based or digital video interactions in education to prevent dropout rates or disengagement.

The new educational scenarios that enable the construction of emerging environments or contexts by incorporating 3D OER are influenced by three significant factors: the presence of the Internet, accompanied by artificial intelligence, semantic web, networks, and cloud computing, which promote and develop new ways of thinking, producing, communicating, researching, knowing, working, learning, and teaching. Simultaneously, there's an increasing availability of free and open technological resources (simulations, remote laboratories, videos, blogs, podcasts, forums, etc.). Additionally, there's a growing access to technology by potential students (Internet, iPod, netbook, tablet, smartphone, etc.). Emerging technologies are gradually being integrated into various levels of formal and non-formal education.[26]

In this sense, Emerging Pedagogy and Emerging Technologies enable the creation of complex environments. These encompass communities like the maker community and the open educational movement within the framework of knowledge societies and open science. This is due to the understanding that knowledge surpasses the static content found in traditional learning resources. Once appropriated by an individual, it assumes dynamic aspects, leading to evolution through new applications. In addition, having confidence in social interaction is essential for cultivating a sense of security and well-being within a maker community. On the other side, simple communication ensures that significant ideas arise from simplicity rather than complexity, enabling collaborative efforts with contributions from diverse backgrounds. Finally, maintaining a high level of tolerance for experimentation and failure is crucial in the learning process," [27] as suggested by this author. Some key elements necessary for establishing a learning ecosystem include: We can say that a maker community incorporates elements of a learning ecology, which is a proposal that summons a favorable environment for learning, enhancing the acquisition of knowledge in varied and enjoyable ways. In addition, it uses physical spaces that prevent overcrowding; it is adaptable to learning timelines and does not pressure or expose individuals to an unpleasant environment that impacts learning. Emerging pedagogies and emerging technology contribute by providing simple and safe spaces that promote co-construction, dialogue, and debate.[28]

We refer to activity settings similar to those offered by maker communities in face-to-face, hybrid environments, and virtual worlds or environments, communities centered around interest, practice, and learning, as well as online gaming platforms. It's important to highlight that ICT-3D OER not only contribute to the emergence of new learning opportunities but also play a crucial role in strengthening traditional activity settings and developments (family, community, cultural and leisure institutions, or work) as potential opportunities for learning.

The concept of "seamless learning" refers to the constant experience of learning that individuals undergo, regardless of the places, situations, times, and institutional contexts in which they learn.[29] ICT-3D OER enable the "seams" and "discontinuities" between learning experiences that occur in different places, times, and socio-institutional contexts to blur and sometimes even disappear. In other words, these technologies enable us to contemplate a learning model where learners can pursue their interests in different moments and activity contexts. They can do so by swiftly and effortlessly transitioning from one context to another.[30] Technologies also make it possible to create personal digital learning environments that incorporate and merge resources and tools of diverse natures and origins, customized to learners' interests and preferences regarding their educational journey.[31]

Bozalek *et al*. mention Herrington *et al*.'s study on the contribution of Emerging Technology to enhance learning. They argue that emerging technologies have the potential to foster several characteristics of authentic learning, such as remote collaboration, sharing of outcomes, communication with experts, and access to online research communities.[32,33] Emerging technologies that appear to offer authentic learning opportunities are those supporting collaboration (e.g., digital databases, social networks tools, and reference tools), enabling collective knowledge building (e.g., role-playing, problem-based activities, case-based learning, discussion forums, and virtual communities of practice), and allowing individual or group expression (e.g., blogs, e-portfolios, and video devices).[34]

Herrington and Parker suggest that the reason for the lack of integration of emerging technologies in higher education courses could be the gap between tools used for learning and those employed in contemporary daily life. Despite students' basic tech skills, their personal use of mobile technologies is on the rise. This increase is not just due to social networking trends but also for accessing diverse online resources, providing easy information access and web-based publishing opportunities.[29,33] Using Web 2.0 technologies empowers learners to potentially transform the educator-student relationship through key activities, as highlighted by

Lee and McLoughlin. These activities include connectivity, content creation, and gathering and aggregation of information into online spaces. Leveraging the capabilities and potential of these web-based applications presents a substantial challenge for the teaching community.[35]

In educator training, it becomes imperative to employ emerging technologies because educators hold the responsibility of preparing future professionals, and among their students, there may also be potential future educators.[35]

Oppenheimer has criticized the conventional approach to educating teachers in technology usage, which typically occurs in computer labs, detached from regular classroom activities. He compared this method to teaching the hammer instead of teaching carpentry. This approach corrects the strategy centered on specific software or programs, inviting educators to implement innovative ideas directly in the classroom. Thus, highlighting the importance of maker pedagogy.[36]

The use of 3D printing proves to be a valuable asset in the odontology field, providing students with a clearer and more tangible understanding of dental anatomy and oral structures.[37,38]
Some ways in which 3D printing is used for odontology training are:

1. Study models: They facilitate the creation of accurate dental models for students to manipulate and examine closely. These can be helpful for understanding dental anatomy and treatment planning.
2. Simulation of procedures: It enables the development of models that simulate dental procedures, such as dental prosthesis placement or surgical procedures. These models can be useful for practice and skill development in the teaching environment.
3. Clinical case analysis: It allows students to analyze and discuss models based on real clinical cases. This can aid in promoting critical thinking and decision-making within the clinical environment.

In summary, 3D printing serves as both a cultural artifact and a valuable tool in dental training. It enables students to gain a clearer and more tangible understanding of dental anatomy and oral structures. Additionally, it supports the practice and development of teaching-related skills.[39]

The combination of maker pedagogy and 3D printing can prove to be a valuable asset in learning and developing clinical skills within the health sciences field. It enables the creation of accurate, realistic models while promoting a more engaging and participatory learning approach.[40,41]

CONCLUSIONS

OER play a crucial role in contemporary education, particularly in a post-pandemic context. Their unrestricted access and the possibility to adapt and distribute them at no cost make them valuable tools for teaching and learning, particularly in circumstances where physical access to educational institutions is restricted.

The inclusion of ICT has substantially changed education, enabling more interconnected and digital learning environments. This has been notably significant during the COVID-19 pandemic, where remote teaching and hybrid approaches have gained unparalleled significance.

Despite being available and beneficial, there is a widespread lack of awareness and limited integration of OER in university education. This suggests the need for increased promotion and training on the use and potential of these resources. Moreover, it underscores the importance of adapting pedagogical strategies to effectively incorporate them into teaching and learning processes.

The pandemic has driven the need for innovation and adaptation of pedagogical methods. This involves not only the adoption of technologies like 3D printing and augmented reality, but also a shift towards more collaborative and participatory approaches in education, as demonstrated by the growing influence of maker pedagogy. These changes seek to respond to the emerging needs and challenges faced by educators and students in the actual context.

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CONFLICT OF INTEREST

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