Seminars in Medical Writing and Education. 2025; 4:450
doi: 10.56294/mw2025450

REVIEW

Transforming the classroom into Higher Education: The Synergy between Design Thinking, the TPACK Model, and Open Educational Resources

Transformando el Aula en la Educación Superior: La Sinergia entre el Design Thinking, el Modelo TPACK y los Recursos Educativos Abiertos

Lilian Gabriela Valencia Turcotte[1], José Antonio Jerónimo Montes[1]

[1]Universidad Rosario Castellanos (URC), Doctorado en Ambientes, Sistemas y Gestión en Educación Multimodal, Ciudad de México, México.

Cite as: Valencia Turcotte LG, Montes JAJ. Transforming the classroom into Higher Education: The Synergy between Design Thinking, the TPACK Model, and Open Educational Resources. Seminars in Medical Writing and Education. 2025; 4:450. https://doi.org/10.56294/mw2025450

Submitted: 01-02-2024 **Revised:** 28-07-2024 **Accepted:** 12-01-2025 **Published:** 13-01-2025

Editor: PhD. Prof. Estela Morales Peralta

Corresponding Author: José Antonio Jerónimo Montes

ABSTRACT

This study proposed the transformation of higher education teaching through the synergy of Open Educational Resources (OER), the TPACK model, and the *Design Thinking* methodology. It focused on the learning of stereochemistry and isomerism of biomolecules within the Biology degree program at the Facultad de Ciencias, UNAM, under a new curriculum based on Kolb's experiential learning model. During the COVID-19 pandemic, the need for flexible, ICT-supported methodologies became evident. In this context, OER served as key tools to democratize knowledge and promote autonomous and collaborative learning. The TPACK model enabled the integration of content, pedagogy, and technology, while *Design Thinking* provided a student-centered structure for solving complex problems through empathy, creativity, and experimentation. The methodological strategy was structured around six instructional actions; each linked to expected outcomes. Students followed an experiential learning process divided into four stages, in which specific actions, resources, and prototyping activities were defined. The approach included the manipulation of three-dimensional molecular models to encourage interdisciplinary, hands-on learning under the *Design Thinking* framework. This strategy enhanced students' conceptual understanding and ability to apply knowledge in real-life contexts through active experimentation. The proposal emphasized the need for continuous teacher training and institutional support to ensure the successful adoption of these innovative practices in higher education.

Keywords: *Design Thinking*; Open Educational Resources; Emerging Pedagogy; ICT; Open Pedagogy; TPACK.

RESUMEN

El presente trabajo propone la transformación de la enseñanza universitaria mediante la sinergia de los Recursos Educativos Abiertos (REA), el modelo TPACK y la metodología de *Design Thinking*. La propuesta se centró en el aprendizaje de la estereoquímica e isomería de biomoléculas en la Licenciatura en Biología de la Facultad de Ciencias de la UNAM, bajo el nuevo plan de estudios basado en el modelo de aprendizaje experiencial de Kolb. Durante la pandemia por COVID-19, se evidenció la necesidad de metodologías flexibles e innovadoras apoyadas por TIC. En ese contexto, los REA son las herramientas clave para democratizar el conocimiento y facilitar el aprendizaje autónomo y colaborativo. El modelo TPACK permitió integrar contenidos, pedagogía y tecnología, mientras que *Design Thinking* aportó una estructura centrada en el estudiante para resolver problemas complejos mediante la empatía, la creatividad y la experimentación. Se diseñó una estrategia metodológica a partir de seis líneas de acción docente y los resultados esperados, para los alumnos el proceso de aprendizaje es bajo el modelo experiencial dividido en las cuatro etapas detallando las acciones, recursos y el prototipado. Se propone la manipulación de modelos moleculares tridimensionales para promover una enseñanza activa e interdisciplinaria bajo el modelo del *Design Thinking*. Esta estrategia busca la comprensión conceptual de los estudiantes y su capacidad a través de la experimentación para aplicar el conocimiento en contextos reales. La propuesta destacó la necesidad de formación docente y el acompañamiento institucional para consolidar estas innovaciones en la educación superior.

Palabras clave: *Design Thinking*; Recursos Educativos Abiertos; Pedagogía Emergente; TIC; Pedagogía Abierta; TPACK.

INTRODUCTION

Historically, we can consider the beginning of resource-supported education to be the invention of the printing press by Gutenberg in the 15th century. Thus, the first printed books were the link between the author and the reader. In the last century, the World Wide Web (Web 1.0) was unveiled. Since then, there has been rapid growth in the use of the Internet in education, with the University of Phoenix being a pioneer in educational programs through the Web.[1] It was the first impulse to share educational content for teaching.

Nowadays, a higher degree of interactivity has been achieved through social networks and multimedia technology, as communication is bidirectional with Web 2.0 and Web 3.0. In 2020, an unprecedented learning experiment was written into the history of humanity,[2] as millions of children and young people were forced to use information and communication technologies (ICT) due to the social distancing measures originated by the COVID-19 pandemic to maintain continuity in their education. This period was referred to as "emergency remote teaching." It was characterized by the use of the bidirectional Web for distance communication between teachers and students, with educational resources accessible under these circumstances.

The incorporation of ICTs represents a way to strengthen the formative processes of both students and teachers.[3] The role of ICTs in the current educational context and the post-pandemic challenges make evident the need to transform traditional teaching classrooms with methodological approaches that respond creatively to the needs of students. This paper is expected to provide ideas for the use of strategies that take advantage of the synergy of Open Educational Resources (OER) with student-centered methodologies, such as Design Thinking, and techno-pedagogical models, such as TPACK (Technological Pedagogical Content Knowledge) to innovate teaching, promote student-centered, active, collaborative learning and prepare students to face complex real-world problems.

The Use of Open Educational Resources to meet the challenges of higher education

Educational materials and resources play a crucial role as mediators of the teaching and learning process. According to Marqués[4], it is essential to distinguish between Educational Media, which are designed for educational purposes, and Educational Resources, which may not have been initially created for that purpose but are used for pedagogical purposes. Open Educational Resources (OER), as defined by UNESCO[5], "are teaching, learning and research materials available in a variety of formats that belong to the public domain or have been published under open licenses." Educational content such as collections, complete courses, texts, videos, audios, repositories, learning objects, interactive materials, apps, software, and platforms for creating resources are considered OER as long as they meet the requirements of being accessible to everyone regardless of geographic location or economic situation, promote the democratization of knowledge by having non-commercial licenses and can be freely adapted and shared to meet particular teaching needs. Those resources that are not in the public domain or do not have an open license are not considered OER. Neither are those that are free but not open, i.e., those that are accessible on the Internet but are copyrighted.

OER are characterized by copyright licenses that allow everyone to participate in the activities known by their acronym as the 5Rs, which are: Retain, Reuse, Revise, Remix, and Redistribute.[6] Angulo[7] refers to this as freely available educational content that is under Creative Commons (CC)[8] or other similar licenses. These licenses belong to a governmental, non-profit organization and fall somewhere between the "public domain" and "all rights reserved" categories. CC licenses allow authors to choose between six types of protection for their work, ranging from the least to the most restrictive. They are identified with a combination of symbols, in which, in all cases, they maintain the author's rights and, in turn, the credit that corresponds to them.[9]

Educational problems in higher education

The arrival of the COVID-19 pandemic has accelerated the design and use of OER. The world's educational institutions with face-to-face models had to adapt quickly to emergency remote teaching, which demanded the use of ICT to create educational resources tailored to the desired content. One example was the National Autonomous University of México (UNAM), which, before the pandemic, had teachers and a solid structure for online teaching. Their advice, methodologies, and experience helped other face-to-face teachers in the transition to the forced distancing caused by the pandemic.[10] Educational resources were also shared; however, it quickly became evident that educational resources were scarce, commercial, or under non-permissive licenses. In recent years, UNAM, as part of its institutional policies, has promoted the University Learning Network (https://www.rua.unam.mx/), the Digital Learning Environments (https://ada.educatic.unam.mx/), and more recently, the UNAM-RETo platform (https://reto.cuaed.unam.mx/) to consolidate OER repositories. These platforms aim to provide access to reliable, freely available materials, fostering academic collaboration and technology-mediated learning. However, there are still limitations, such as a lack of knowledge about these tools, the need for teacher training, and the underrepresentation of content in the areas of science and health.[11]

In the field of university education, especially in areas such as biochemistry, chemistry, or molecular biology, OER can take the form of virtual simulations, interactive infographics, scientific articles, databases, or explanatory videos that, when integrated into teaching strategies, facilitate the understanding of complex phenomena and strengthen both autonomous and collaborative learning. From the teaching perspective, OER enhances the organizational function of didactics since they can be selected, adapted, and combined according to the needs of the students, the nature of the content, and the pedagogical objectives.[12]

Despite their advantages, OER still faces obstacles to their consolidation in higher education. Lack of dissemination and poor teacher training constitute relevant barriers. Many teachers are unaware of these resources or do not know how to incorporate them into their curricula. A study conducted in 2019[13] with 192 teachers showed a favorable attitude towards the use of open data in education, although it also showed limited digital competence, which hinders its practical application. Similarly, a good disposition towards OER was identified at the Universidad Autónoma del Estado de México. Still, they emphasized the need for ongoing training.[14] These findings suggest that, although faculty recognize the educational potential of OER, significant challenges persist in their implementation. The absence of strong curricular training programs impedes a broader and more effective use of these resources in university classrooms.

The TPACK model and Emergent Pedagogy

The post-pandemic context has generated essential reflections on the teaching role in non-face-to-face environments, where intensive use was made of technological tools to achieve learning objectives.[14,15] These changes evidence the dynamic nature of pedagogy, which evolves and adapts to contemporary challenges. Pedagogy goes beyond the mere application of techniques and technology; at this point, didactics is very important, acting as a bridge between pedagogical theory and teaching action, guiding decisions on what to teach, how to prepare, with what resources, and for what purpose, always according to the context and expected learning outcomes. One methodology for teachers to effectively integrate technology into their teaching practice is the TPACK model.[16]

The Technological Pedagogical Content Knowledge (TPACK) model gained incredible popularity during and after the COVID-19 pandemic due to its benefits of integrating technology with pedagogy by adapting educational content to facilitate teaching (figure 1). Dolores[17] argues that the TPACK model contributes to teachers' mastery of their area of knowledge but also provides them with a deep understanding of teaching processes, evaluation, and the use of technological tools.

The TPACK[18] model includes three basic categories of knowledge:

- **CK:** content knowledge (of the subject matter to be taught) or the teacher's understanding of the subject matter to be learned or taught,
- **PK:** and pedagogical knowledge refer to the methods and strategies used for teaching and learning. The teacher possesses a deep understanding of teaching-learning methods and processes, and
- **TK**: technological knowledge, which is the teacher's understanding of and skill in incorporating technological resources and tools.

This model identifies the knowledge that teachers need to optimize teaching through the use of technology[19] and is not simply the incorporation of technology. TPACK is typically represented in a Venn diagram, as the three fundamental domains — CK, PK, and TK — are articulated. The interrelationship between these components gives rise to three intersectional areas, the PCK, TPK, and TCK, which guide teachers in their educational practices (see Figure 1).

The concept of open pedagogy has gained momentum lately in the framework of technological development and learner-centered approaches; it is defined as "the openness of educational processes, enabled by Web 2.0 technologies".[20] In the same vein, Weller[21] highlights the central role of open content and networked interaction as distinctive elements of this approach, establishing a direct link with OER. In more recent years, the concept of *OER-enabled pedagogy* has been proposed, understood as a set of educational practices that are only possible thanks to the flexible use permissions that characterize these resources.[6]

The new scientific knowledge on the functioning of the brain, and especially the progressive incorporation

https://doi.org/10.56294/mw2025450 ISSN: 3008-8127

of ICT in the classroom, has propelled multiple innovations in recent years, grouped under the denomination of emerging pedagogies.[22,23,24] They emerge as developing approaches that respond to new educational realities without constituting a total rupture with the previous. In 2019, pedagogical innovations were classified into four major approaches according to their educational goals and the didactic principles that support them.[25] One of them is "experiential and inquiry learning," a classical method of experiential learning, active learning, or inquiry-based learning. It develops the modern principles of constructivism and teaching by competencies.[26] In this educational approach, the individual inquiry is privileged for problem-solving and collaborative discussion, and conclusions are reached. *Design Thinking,* also known as "design thinking," is considered an emerging method that builds upon the same principles of learning by discovery and PBL.

Design Thinking

Teachers do not hesitate to affirm the importance of helping students to develop a more creative and critical way of thinking in the resolution of conflicts and real-life problems through processes of analysis and evaluation of these and the subsequent proposal of solutions to them.[27] It is in these areas aimed at solving complex problems and experiential learning that Design Thinking has its most significant presence.[28,29]

Design Thinking is a methodology that encourages collaboration among students to design creative solutions, initially inspired by the human-centered design model (IDEO), keeps users at the center of the whole process and promotes empathy in all those who are encouraged to experiment.[30] Since its beginnings, Design Thinking has been related to the principles of experiential learning, initially popularized by Kolb[31]

Design Thinking (figure 1) goes through six interconnected stages through an interactive process:[32]

1. Understand: investigate and empathize with the needs and desires of the users.
2. Define: delimit the problem and establish a clear vision.
3. Ideate: generate creative ideas and innovative solutions.
4. Prototype: create prototypes to visualize and test our ideas.
5. Test: evaluate prototypes with real users and collect feedback.
6. Refine: Based on the results obtained, adjust and improve the solutions.

OER and Design Thinking are closely related, as their purpose is to create educational solutions. Both share a focus on the learner, on understanding their needs and challenging them to develop practical and innovative solutions. They are flexible and adaptable, enabling them to overcome educational challenges. In addition, they allow the creation of a community by collaborating in teams, i.e., thinking in an interactive process to think collectively within that process.

Maker Culture and OER Design

The definition of "maker" refers to an individual who participates in the maker and fabrication movement, characterized by a "do it yourself" mentality.[33] Makers form communities where they can experiment, design, build, and create unique artifacts. This concept is linked to active learning and knowledge building through the creation of tangible objects, promoting innovation, collaboration, and the development of practical and technological skills. The maker community and Design Thinking have driven innovation proposals, such as educational robotics or 3D design.[34] Unlike problem-based learning (PBL) methodology, Design Thinking involves the construction of technological material in response to an authentic problem where students are motivated to seek solutions through inquiry, trial and error until the learning process materializes. The response to the problem culminates in a concrete product achieved with the help of both the teacher and their peers. In this way, the student acts individually, confronting the specific problem, designing an answer, and materializing it after collective learning through trial and error, ultimately ending with a prototype and, finally, a product. In this way, mistakes are not perceived as failures but rather stimulate the student to reach a solution collectively.

Currently, there are few examples of these methodologies being implemented in education. One of them is the university experience at the Facultad de Estudios Superiores Zaragoza of the UNAM, in the Dentistry degree program, where 3D printing technology has been implemented to generate anatomical models from real CT scans.[32] This innovation has not only improved the understanding of complex content but also encouraged project-based learning, collaboration among peers, and the creation of maker communities, promoting the "students for students" approach. Experience shows that practical implementation of OER requires facing resistance to change and providing adequate teacher training and support.

Methodology of educational intervention

The Faculty of Sciences at UNAM has recently begun implementing a new curriculum for the Bachelor's Degree in Biology. It maintains a face-to-face model, incorporating suggestions for activities that utilize ICT. The plan is based on Kolb's learning model and is organized in two stages: Basic Training and Deepening. The first addresses the fundamental concepts of biology, such as learning the stereochemistry and isomerism of biomolecules. This proposal diverges from the transmissive approach of the previous plan, adopting a more active teaching approach where the teacher acts as a guide and facilitator of learning. In this context, OER is key to the transition of curricula and contributes to experiential teaching and learning.

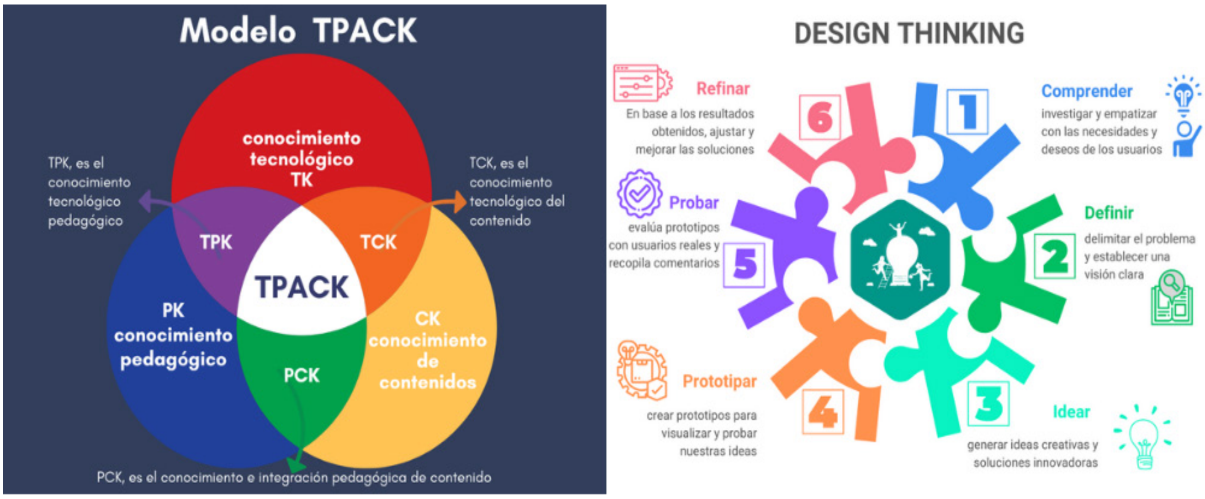

Figure 1. The TPACK Model and the Design Thinking methodology

The proposal presented here is student-centered to promote the understanding of the three-dimensional structures of biomolecules (stereochemistry and isomerism) under the experiential model. Three key components are articulated: the OER, the TPACK model, and the Design Thinking methodology (figure 2). Based on these approaches, a didactic sequence was structured according to the four stages of Kolb's cycle (table 1). In each phase, the teacher's actions, the resources to be used (with the OER approach), the digital tools, and the expected products as evidence of learning were specified, highlighting the creation and manipulation of three-dimensional molecular models. The proposal is contextualized within the university teaching of biological sciences, incorporating an interdisciplinary approach (chemistry, biology, and technology) and utilizing physical and virtual materials accessible on UNAM digital platforms.

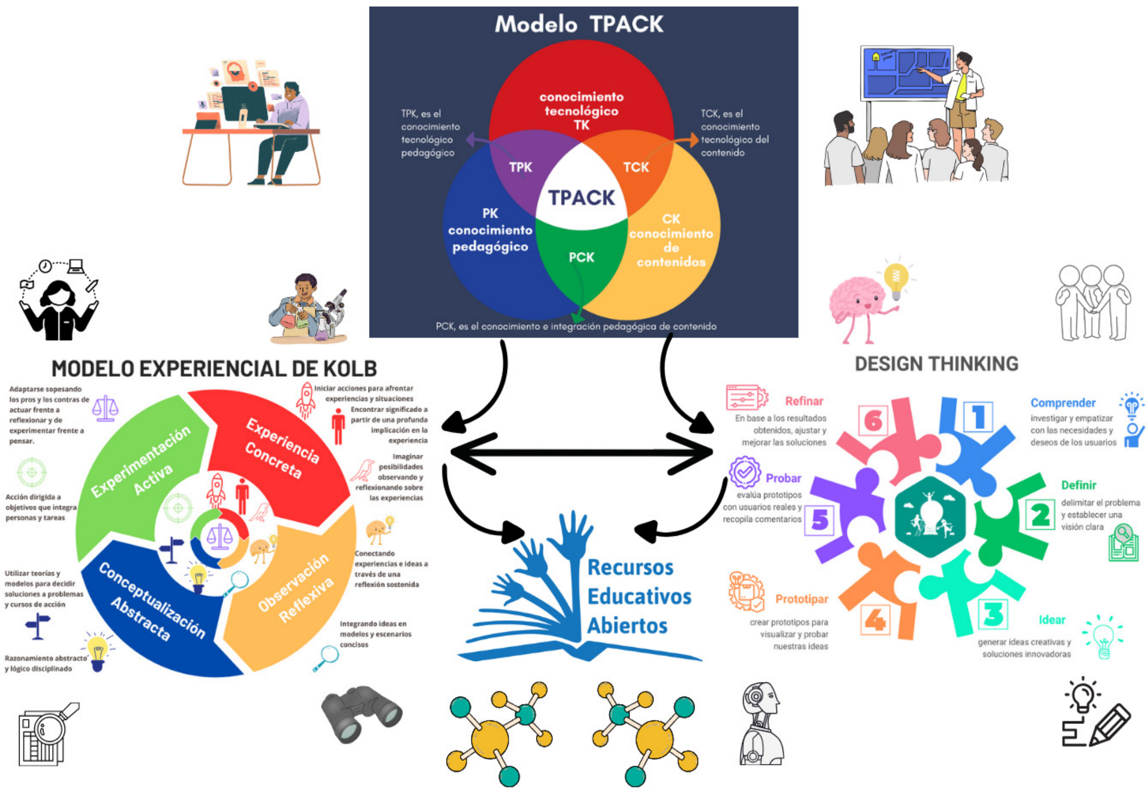

Figure 2. Methodological strategy for learning stereochemistry and isomerism of biomolecules based on Kolb's experiential learning model, integrating Open Educational Resources (OER), using the TPACK model and Design Thinking methodology

https://doi.org/10.56294/mw2025450 ISSN: 3008-8127

RESULTS

Table 1. Teaching lines of action for learning stereochemistry and isomerism of biomolecules based on Kolb's experiential learning model, integrating Open Educational Resources (OER), using the TPACK model and Design Thinking methodology

Lines of action	Teacher action	Outcome
Diagnosis	Surveys, interviews, analysis	Identification of needs. Search for possible existing OER.
Problem definition	Research question	Analysis of the educational environment
Planning	Selection of appropriate content, strategies, pedagogies and technologies with TPACK model.	Didactic Sequence Design
Response	Collaborative elaboration of materials	OER ready for classroom implementation
Implementation	In the classroom	Based on the experiential model
Evaluation and improvement	Collect evidence	Feedback, re-design

The implementation of the methodological strategy was structured around six lines of action, articulated under Kolb's experiential learning approach, the TPACK model, and the use of OER. First, through surveys, interviews, and contextual analysis, students' needs were identified, and existing OER relevant to the content was sought. Subsequently, in the problem definition phase, a research question is formulated to guide the analysis of the educational environment, orienting the proposal towards a specific pedagogical challenge. In the planning stage, the teacher proposes content, strategies, active pedagogies, and technological tools based on the TPACK model to design a student-centered instructional sequence. During the response phase, the teacher promotes the collaborative work of open educational materials, generating OER adapted to the teaching context. These materials are implemented in the classroom based on the experiential learning model, allowing students to interact with the contents actively. Finally, an evaluation and improvement stage is applied to collect evidence of the process and the learning that has been achieved. Feedback enables the redesign of elements within the didactic sequence, reaffirming the importance of iterative cycles for the continuous improvement of educational practices.

The process for students begins with Kolb's model, with concrete experience interacting with three-dimensional molecular models (physical or digital), selected or designed as OER, representing different types of isomerism and relevant stereochemical configurations in biomolecules. In reflective observation, students use videos and visual materials to compare structures, recognize spatial patterns, and record their observations. This can be integrated by elaborating infographics in collaboration with their peers to promote critical analysis. Subsequently, the integration of content leads to the formation of abstract, conceptualized ideas. The selection and use of these materials align with the TPACK model, integrating content knowledge with active pedagogical strategies. Finally, in the active experimentation phase, students design, build, or manipulate three-dimensional models as a final product using molecular modeling or 3D printing software. This product is accompanied by an oral or written presentation that justifies the choice of the represented structure, explains its biological relevance using concrete examples of carbohydrates or proteins, and argues the relationship between form and function.

Throughout Kolb's cycle, the stages of Design Thinking are applied by prioritizing student needs, defining learning challenges, devising didactic solutions, prototyping OER, and evaluating their impact. This methodological integration enables the design of teaching-learning experiences that promote critical thinking, spatial visualization, and an understanding of the structure and function of biomolecules.

DISCUSSION

From a pedagogical perspective, this proposal represents a break with traditional approaches, as it invites the transformation of the classroom. The incorporation of the TPACK model provides a framework for selecting the appropriate technology and linking it to content and pedagogical strategies. OER serves as an adaptable resource to implement this approach, and *Design Thinking* is the methodology that converts planning into a meaningful, student-centered experience, promoting dynamic and shared learning environments. Additionally, it encourages the development of collaborative communities between teachers and students, fostering peer learning, knowledge co-creation, and the production of reusable resources. The articulation between OER, *Design Thinking,* and TPACK not only addresses current challenges but also proposes an innovative and sustainable approach to current teaching. A way in which the student becomes a designer and constructor of knowledge without fear of error; the teacher, a facilitator, and guide; and technology, a bridge to experiential learning.

In these times of significant technological advancements, such as Artificial Intelligence, it is essential to stimulate students to think critically and creatively, especially in the face of real-life challenges. In the future, an evolution towards pedagogies that are more connected to real problems is on the horizon. If "design thinking" is incorporated as a methodology in the classroom, it will enable students to identify complex problems, empathize with their peers, and together devise innovative solutions and prototype assertive educational responses. This approach is particularly valuable in fields such as biology, chemistry, and health, where conceptual abstraction can benefit significantly from strategies based on prototypes, simulations, and artifact construction.

However, implementing these ideas requires overcoming significant challenges. Some of them are teacher training in digital competencies, equitable access to technology, and the culture of sharing free-to-use educational resources. Therefore, it is evident that institutional programs for the development of digital skills among teachers should be promoted in their teaching practices and instructional designs that encourage the critical and reflective use of ICT and shared with other teachers, particularly within the framework of generating educational resources aligned with the characteristics of OER. This is the only way to move towards a model of higher education that is more open, creative, participatory, and aligned with the needs of today's society.

On the other hand, the transition to the new plan of the Faculty of Sciences at UNAM faces a series of significant challenges in training human resources capable of designing, developing, and integrating OER. One of the main challenges is the lack of pedagogical training with a techno-pedagogical approach among teachers, many of whom have a solid disciplinary background in science but lack knowledge in instructional design. Another relevant challenge is the lack of understanding of the benefits **of** Creative Common licenses. Additionally, traditional models of transmissive teaching persist, failing to promote authorship, adaptation, or collaboration in the creation of resources. Finally, it is essential to encourage institutional strategies that incorporate teacher training programs, as well as policies that value and recognize teachers for their contributions to the production of OER as part of their academic work. Only in this way will it be possible to consolidate a community of practice that promotes the use of OER to overcome the challenge of the new educational model in the undergraduate biology program at the Faculty of Sciences, UNAM.

CONCLUSIONS

The synergy of OER, the TPACK model, and the Design Thinking methodology in higher education represents a timely response to the pedagogical challenges posed by global health emergencies, as well as those that follow them, or by a change in educational models, as in the case of the Faculty of Sciences at the UNAM. This approach enabled the coherent integration of content, pedagogy, and technology, which favors conceptual understanding through experimentation and collective problem-solving. The present work represents a robust pedagogical strategy for transforming university teaching in scientific contexts. The described strategy for learning stereochemistry and isomerism of biomolecules demonstrates that it is possible to promote a more active, interdisciplinary, and student-centered educational approach through the use of open technologies, creative thinking, and an experiential approach.

Significant challenges were identified. These include limited teacher training in the use and production of OER, the lack of institutional recognition of the academic work associated with their creation, and the need to strengthen a critical and open digital culture within the scientific community. It is essential to establish institutional strategies that promote teacher training, interdisciplinary collaboration, and recognition and incentives for the creation and dissemination of OER. Only in this way will it be possible to consolidate an open educational system adapted to the demands of higher education in the 21st century.

REFERENCES

1. Kentor H. Distance education and the evolution of online learning in the United States. Curric Teach Dialogue. 2015;17(1-2).

2. Zimmerman J. Coronavirus and the great online-learning experiment. Chron High Educ [Internet]. 2020 [citado 2025 jun 22]. Disponible en: https://www.chronicle.com/article/coronavirus-andthe-great-online-learning-experiment/

3. Méndez-Encarnación D, et al. El aula del futuro: una herramienta para transformar la práctica educativa en la BUAP. En: Perspectivas de la innovación educativa en universidades de México. Ed. Imagia Comunicación; 2018. p. 321.

4. Marquès P. Los medios didácticos [Internet]. 2011 [citado 2025 jun 22]. Disponible en: http://peremarques.net/medios.htm

5. UNESCO. Recomendación sobre los recursos educativos abiertos (REA) [Internet]. París: Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura; 2019 [citado 2025 jun 22]. Disponible en: https://unesdoc.unesco.org/ark:/48223/pf0000383205_spa

6. Wiley D, Hilton J. Defining OER enabled pedagogy. Int Rev Res Open Distrib Learn. 2018;19(4):133–46. https://doi.org/10.19173/irrodl.v19i4.3601

7. Angulo N. Glosario de la docencia en la sociedad del conocimiento. Ciudad de México: Coordinación Editorial de la Secretaría Académica del Instituto Politécnico Nacional.

8. Creative Commons, U.S. Department of Education, Open Society Foundations. FAQ – Why open education matters [Internet]. 2012 [citado 2025 jun 22]. Disponible en: http://whyopenedmatters.org/faq/

9. Becerril JL, Campero E, Fraire M, Fuentes JD, Hernández M, Mendoza L, et al. Guía práctica para implementar una estrategia de docencia a distancia en situación de emergencia [Internet]. CUAED-UNAM; 2020 [citado 2025 jun 22]. Disponible en: https://cuaieed.unam.mx/descargas/Guia-practica-para-implementar-una-estrategia-de-docencia-a-distancia-en-situacion-de-emergencia.pdf

10. Cabrera Coronel AM, Centurión de Gómez NS, Mora Rojas CO. Virtualización de clases presenciales en la universidad. Educ Quím. 2022;33(3). http://dx.doi.org/10.22201/fq.18708404e.2022.3.80254

11. Universidad Nacional Autónoma de México. Primera evaluación de la Red Universitaria de Aprendizaje [Internet]. Ciudad de México: UNAM; 2024 [citado 2025 jun 22]. Disponible en: https://educatic.unam.mx/lad-unam/evaluacion-rua.pdf

12. Hilton J, Gaudet D, Clark P, Robinson J, Wiley D. The adoption of open educational resources by one community college math department. Int Rev Res Open Distance Learn. 2013;14(4):37–50.

13. Rivas-Rebaque B, Gertrudix-Barrio F, de Cisneros de Britto JC. La percepción del docente universitario ante el uso y valor de los datos abiertos. Educ XX1. 2019;22(2):141–63. https://doi.org/10.5944/educXX1.21317

14. Torres Velandia SÁ, Jerónimo Montes JA. Recursos educativos abiertos, retos y oportunidades en tiempos de pandemia: estudio de caso, México. RECIE Rev Electr Científica Investig Educ. 2021;5(2):199–214. https://doi.org/10.33010/recie.v5i2.1439

15. Lira López L, Uribe López A. Pedagogías emergentes desarrolladas en educación superior a partir del confinamiento por la COVID-19. Apertura. 2022;14(1):114–31. http://dx.doi.org/10.32870/Ap.v14n1.2149

16. Rosenberg J, Koehler M. Context and technological pedagogical content knowledge (TPACK): a systematic review. J Res Technol Educ. 2015;47(3):186–210. https://doi.org/10.1080/15391523.2015.1052663

17. Dolores M. Proceso de enseñanza: ¿cuál es el mejor? TecReview [Internet]. 2021 [citado 2025 jun 22]. Disponible en: https://tecreview.tec.mx/2021/09/30/tendencias/proceso-de-ensenanza

18. Koehler MJ, Mishra P. What is technological pedagogical content knowledge? Contemp Issues Technol Teach Educ. 2009;9(1):60–70. https://bit.ly/3n9wYjV

19. Salas-Rueda RA. Modelo TPACK: ¿medio para innovar el proceso educativo considerando la ciencia de datos y el aprendizaje automático? Entre Cienc. 2019;7(19). https://doi.org/10.22201/enesl.20078064e.2018.19.67511

20. Hodgkinson-Williams C, Gray E. Degrees of openness: the emergence of open educational resources at the University of Cape Town. Int J Educ Dev ICT. 2009;5(5):101–16.

21. Weller M. The battle for open: a perspective. J Interact Media Educ. 2013;(3):Art. 15. https://doi.org/10.5334/2013-15

22. Adell J, Castañeda L. Tecnologías emergentes, ¿pedagogías emergentes? En: Hernández J, Pennesi M, Sobrino D, Vázquez A, coordinadores. Tendencias emergentes en educación con TIC. Barcelona: Asociación Espiral, Educación y Tecnología; 2012. p. 13–32.

23. Sánchez-Mendiola M, editor. Glosario de innovación educativa: lista de términos clave. Ciudad de México: Universidad Nacional Autónoma de México; 2022. ISBN: 978-607-30-5658-8.

24. Toledo Lara G. Pedagogías emergentes: una aproximación exploratoria. Aposta Rev Cienc Soc. 2021;(91):98-113. Disponible en: http://apostadigital.com/revistav3/hemeroteca/toledolara.pdf

25. Montanero Fernández M. Métodos pedagógicos emergentes para un nuevo siglo: ¿qué hay realmente de innovación? Teor Educ Rev Interuniv. 2019;31(1):5-34. https://doi.org/10.14201/teri.19758

26. Díaz-Barriga FA, Hernández-Rojas G. Estrategias docentes para un aprendizaje significativo: una interpretación constructivista [Internet]. Disponible en: https://dfa.edomex.gob.mx/sites/dfa.edomex.gob.mx/files/files/2_%20estrategias-docentes-para-un-aprendizaje-significativo.pdf

27. Latorre-Cosculluela C, Vázquez-Toledo S, Rodríguez-Martínez A, Liesa-Orús M. Design Thinking: creatividad y pensamiento crítico en la universidad. Rev Electr Investig Educ. 2020;22:e28. https://doi.org/10.24320/redie.2020.22.e28.2917

28. Beckman SL, Barry M. Innovation as a learning process. Embedding Design Thinking. Calif Manage Rev. 2007;50(1):25-57. https://doi.org/10.2307/41166415

29. Elsbach KD, Stigliani I. Design Thinking and organizational culture: a review and framework for future research. J Manag. 2018;44(6):2274-306. https://doi.org/10.1177/0149206317744252

30. Chin D, Blair K, Wolf R, Conlin L, Cutumisu M, Pfaffman J, et al. Educating and measuring choice: a test of the transfer of Design Thinking in problem solving and learning. J Learn Sci. 2019;28(3):337-80. https://doi.org/10.1080/10508406.2019.1570933

31. Kolb DA. Experiential learning: experience as the source of learning and development. Englewood Cliffs: Prentice-Hall; 1984.

32. Jerónimo Montes JA, Cruz Ramírez JI, Martínez Rodríguez AR, Reyes Barrera ME. El uso y apropiación de recursos educativos abiertos 3D para la integración de las áreas básicas en la práctica clínica. Interdiscip J Didact. 2025;(2):75-92. https://doi.org/10.14198/ijd.28955

33. Quintana-Ordorika A, Garay-Ruiz U, Portillo-Berasaluce J. A systematic review of the literature on maker education and teacher training. Educ Sci. 2024;14(12):1310. doi:10.3390/educsci14121310.

34. Brown T, Wyatt J. Design Thinking for social innovation. Stanford Soc Innov Rev. 2010;8(1):30-5

ACKNOWLEDGMENTS
The present work was developed within the framework of the Doctoral studies in Environments, Systems and Management in Multimodal Education (DASEM) of the Universidad Rosario Castellanos.

FINANCING
The authors did not receive funding for the development of this research.

CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION
Conceptualization: José Antonio Jerónimo Montes and Lilian Gabriela Valencia Turcotte.
Methodology: Lilian Gabriela Valencia Turcotte.
Supervision: José Antonio Jerónimo Montes.
Writing - original draft: Lilian Gabriela Valencia Turcotte.
Writing - revision and editing: José Antonio Jerónimo Montes.