

Effective Strategies for Finding Open Educational Resources in High School

Estrategias efectivas para encontrar recursos educativos abiertos en nivel medio superior

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ABSTRACT

Keywords

Open educational resources; teaching practice; key practices; upper secondary education

In the current digital environment, a wide variety of resources have emerged to support the teaching and learning processes. This research focuses on Open Educational Resources (OER), a technological innovation that, for its effective implementation within educational institutions, requires the active participation of teachers. The main objective of this research was to identify and solve some of the challenges faced by high school mathematics and physics teachers when incorporating OER into their teaching practice. To achieve this, an Open Educational Resources Workshop was designed and implemented. It was a qualitative research study that employs a Participatory-Action-Research methodology in which it was possible to identify repositories and platforms used by participating teachers. This process led to a change in the perception of the factor "Time to find, review, and select OER". The research involved the participation of 20 teachers with experience in teaching mathematics and physics at the high school level, in both urban and regional contexts, with at least one year of experience. This work contributes to the knowledge about the incorporation of OER into high school teaching practice in a Mexican context. In addition, it allows the identification of variations in the 5R model, which provides a framework for the implementation of OER in similar educational contexts.

Palabras clave

Recursos educativos abiertos; práctica docente; prácticas clave; educación media superior

RESUMEN

En el entorno digital actual ha surgido una amplia variedad de recursos destinados a apoyar los procesos de enseñanza-aprendizaje. Esta investigación se centra en los recursos educativos abiertos (REA), una innovación tecnológica que, para su efectiva implementación al interior de las instituciones educativas, necesita de la participación de los docentes. El objetivo general de esta investigación fue identificar y solucionar algunos de los desafíos que enfrentan los profesores de matemáticas y física de nivel medio superior (NMS) al incorporar los REA en su práctica docente, para lo cual se diseñó e implementó un taller de recursos educativos abiertos. Se trató de una investigación de corte cualitativo y metodología investigación-acción-participativa en la que se lograron identificar repositorios y plataformas utilizadas por los maestros participantes. Se logró modificar en jerarquía de importancia el factor "tiempo para encontrar, revisar y seleccionar REA". La investigación contó con la participación de 20 profesores con experiencia en la enseñanza de las matemáticas y la física de NMS, tanto en contextos urbanos como regionales, con al menos un año de trayectoria docente. Este trabajo aporta al conocimiento sobre la incorporación de REA a la práctica docente del NMS en un contexto mexicano. Además, permite identificar variaciones en el modelo de las 5R, lo que proporciona un marco para la implementación de REA en contextos educativos similares.

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INTRODUCTION

Today, technology is increasingly present in the development of society and therefore in the daily lives of students. This phenomenon has involved a restructuring of training methods in the education system, and challenges have been assumed that require different responses according to the demands of the digital age. A reconfiguration of teaching and learning is necessary, as well as the testing of new educational proposals towards a post-academic period (Area, 2021). Now, even with the daily presence of technology, we should not forget what for some authors is fundamental in education: sharing (Cronin, 2017; Jhangiani and Biswas, 2017; Wiley & Hilton, 2019). The teaching-learning process has traditionally been constructed from a teacher who shares his knowledge with his students; Therefore, innovations and technological developments play an important role in the creation of tools in favor of education, which allow diversifying the way in which knowledge is shared and which, in turn, facilitate educational processes and outcomes.

In this digital landscape, from where a great diversity of resources has emerged to support teachers' practices, this research focused on open educational resources (OER), defined as:

Learning, teaching and research materials, in any format and medium, that reside in the public domain or are protected by copyright, that have been published under an open license, which allows access, reuse, adaptation and redistribution at no cost to third parties (Unesco, 2020, p. 212).

Since its inception, OER has been characterized by its flexibility to be modified and adapted according to the needs of the context, establishing itself as a technological innovation in teaching practices (Contreras and Gómez, 2017). It should be noted that although OERs are already concrete possibilities for online higher education (Mallmann and Ferreira, 2017), taking them to other educational levels requires a process beyond making available to teachers and students a wide range of resources. It should be borne in mind that access, use and adoption of OER do not mean that they themselves create innovative environments for education, nor do they have a widespread impact on student learning. For this innovation to be relevant, it is necessary to have accompanying strategies and advice that allow an effective articulation of the OER within the real contexts of the classrooms (Tillinghast, 2020).

For OER to be effectively implemented, an appropriate model for incorporating them into teaching practices is required, as it cannot be assumed that, when accessing valuable content, traditional pedagogical models will inherently change (Geser, 2007); in such a way that if the OER are inserted into traditional teaching practices, without a profound modification in the construction of knowledge, there will be no significant change in the teaching process. It is proposed that, in order to promote significant and lasting transformations, it is essential that teachers

understand the benefits of strategic incorporation of OER in their teaching practices. This approach could not only contribute to improving educational quality through OER-enabled pedagogy, but also increase the affordability of education for students worldwide through cost savings (Wiley and Hilton, 2019).

For example, if we start from the axiom that students learn through practice, we could consider copyright, by prohibiting activities such as copying or creating derivative works without the explicit consent of the holder, greatly limit the ways students can learn (Wiley and Hilton, 2019). In this context, technological innovations emerge as an opportunity for the expansion and democratization of knowledge.

When teaching materials are under open licenses, the tools and methods available for learning are diversified, allowing the student to interact with the educational material in various ways: reusing it, adapting it, combining, sharing or managing it, without infringing copyright and for the benefit of your learning process.

The importance of incorporating OER into teaching practice is that it turns knowledge into a public good, harnessed and shared through technology, for all to use and reuse at convenience (Van & Katz, 2020) which contributes directly to improving the quality of education. Despite the favorable perception that has been generated by including OER in teaching practice, most of the interaction has focused on the search and direct reuse of these resources in the classroom (Contreras and Gómez, 2017). Therefore, teachers often locate and share OER as they find it, without reaching deeper levels of interaction, such as adapting or mixing them.

This study suggests that if teachers assume the role of authors of OER for specific contexts, when considering the institutional plans and programs in which they develop their teaching practice, as well as the characteristics and learning experiences of their students, would start an interactive cycle in which students would continue to adapt, improve and expand the OER initially developed by their teachers. This process, in addition to enriching the resource, promotes collaborative learning and enables a pedagogy based on the permissions granted by Creative Commons (CC) open licenses.

The general objective of this research was to identify and solve some of the challenges faced by higher secondary mathematics and physics (NMS, by its acronym in Spanish) teachers in incorporating OER into their teaching practice, through two specific objectives: the first was to determine the relative importance of the factors influencing the incorporation of OER in teaching practice, while the second was to develop and implement an open educational resources (TREA, by its acronym in Spanish) workshop to provide teachers with the tools and support to effectively find, reuse, adapt and combine OER. These specific objectives focus on identifying and

ranking the factors affecting the integration of OER into mathematics and physics teaching in the NMS, as well as providing a support framework for teachers to incorporate OER into their practice and bring about a change in traditional pedagogical models.

THEORETICAL FRAMEWORK

Almost all models describing the phases of the OER agree that they must be found, adapted and used in different ways in order to be shared (Beaven, 2018). Figure 1 shows the schema of the Wiley model (2014) based on CC open licenses, which considers that a set of key practices, defined as 5R, is carried out.

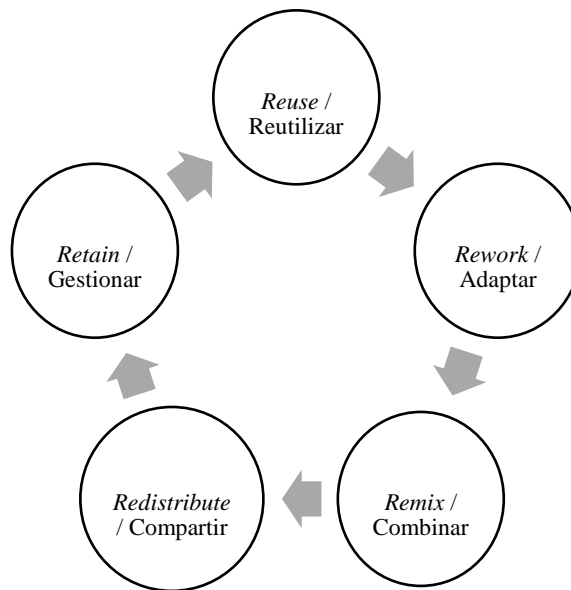


Figure 1. OER life cycle model (Wiley, 2014).

This model considers that OER:

- are used again when shared, copied, distributed, or used as found.
- are adapted when content is altered, modified, transformed or improved to suit the context and the specific needs of users.
- are combined when two or more REA with supported licenses merge creating a new REA.
- are shared, redistributed or disseminated when they are made available to third parties and incorporated into learning, teaching or research processes.
- are managed when copies of content made, held and controlled overtime are systematically recorded in a repository.

Due to the increase of research on the behavior of users when working with OER (Beaven, 2018), the interaction model proposed by Wiley (2014) has not been consolidated as the only one, as other forms of relationships that had not been considered in the original model have been modified and made visible, especially in stages such as reuse and redistribution (Beaven, 2018); however, the 5R model is considered the most appropriate for this research, with an adjustment considering an initial stage called "finding", which happens when identifying the location of an OER and the possible access to it.

Among other aspects that limit the development and use of OER, is the low production of these materials by teachers, especially those developed for academic purposes in contexts other than higher education (Contreras *et al.*, 2017). To this aspect can be added the lack of uniform standards (Khalid *et al.*, 2023) and effective strategies for their use and adoption, as well as strategies to locate these resources quickly and effectively (Otto, 2019). Other authors such as Belikov and Bodily (2016) have identified additional barriers, including insufficient dissemination of OER, difficulties accessing repositories and user confusion in distinguishing OER from other digital materials (Recio *et al.*, 2021).

It is important to note that the low production of OER contrasts with one of its primary characteristics: its open and flexible nature for adaptation. In theory, OER should function as units that can integrate with other resources to form digital entities of greater content and scope, as their licenses allow (Contreras *et al.*, 2017), which stimulates the local creation of knowledge that through the technology of repositories facilitate the exchange, use and distribution on a global scale, with international cooperation (Bozkurt & Gil, 2023).

METHODOLOGY

The type of research proposed is qualitative in nature, which, according to Bautista, "tries to identify the profound nature of realities, their system of relations, their dynamic structure" (2011, p. 16). This uses the methodology of action research, since it deals with the study of a specific social problem that requires solution and affects a certain group of people, which is an ideal methodology for undertaking changes in organizations (Blaxter *et al.*, 2000) and contributing to the development of solutions for specific problems (Bell, 2005). According to Creswell and Creswell (2018) action research focuses on solving a specific and practical problem, and in particular action-participatory research (IPA) "implies a complete and open inclusion of the participants in the study, as collaborators in decision-making, committing themselves as equals to ensure their own well-being" (Creswell, 2012, p. 583).

The methodological design, which generally involves IPA, can be summarized in three phases: the initial phase, which is developed from the first contact and in which the work of detecting needs or problems is organized in order to provide a solution; the intermediate stage, in which the objectives to be achieved are set, assigns tasks and responsibilities and implements information-gathering techniques; and the implementation and evaluation phase, where the achievements of the objectives initially proposed are verified (Bernal, 2010).

Population and sample

In the IAP there is talk of a voluntary non tax action whose determination to collaborate supposes a decision and personal commitment (Contreras, 2002), so the sample for this investigation was selected in a non-probabilistic way, intentional or for convenience. A call was issued to participate in a TREA where teachers with representative qualitative characteristics were sought (Hernández and Carpio, 2019). The following were taken into account for this investigation:

- NMS teachers in the state of Puebla.
- Teaching subjects in mathematics or physics within the NMS.
- Working in a state NMS public institution.
- Interested in improving their teaching practices through technological innovation.

The sample of workshop participants was characterized by the adaptation of an instrument from the Open Education Research Hub (OER Hub), a global organization that conducts research on the impact of OER on teaching and learning practices. Being an open research project, OER Hub

shares its instruments through a package that can be obtained on its website, where all material is available with open license (CC-BY), so it has the permissions to use and adapt it. In this research, some questions of this instrument were translated, selected and adapted, where age, gender, degree of studies, contractual situation, teaching experience and context markers are considered.

The sample was integrated by 20 teachers, who in the development of the workshop provided information on most of the assigned activities; these participated as collaborators according to the proposal of Creswell (2012). The age range ranged from 25 to 64, and they were divided into four ten-year ranks. Regarding the level of studies, it was observed from the undergraduate level to the post-doctoral level, highlighting the presence of master's degrees. The contractual situation varied from teachers with temporary class hours to full-time contracts, the latter being the predominant feature. This reflects a trend in teaching experience, with most participants accumulating more than ten years of experience in relation to groups (see graph 1).

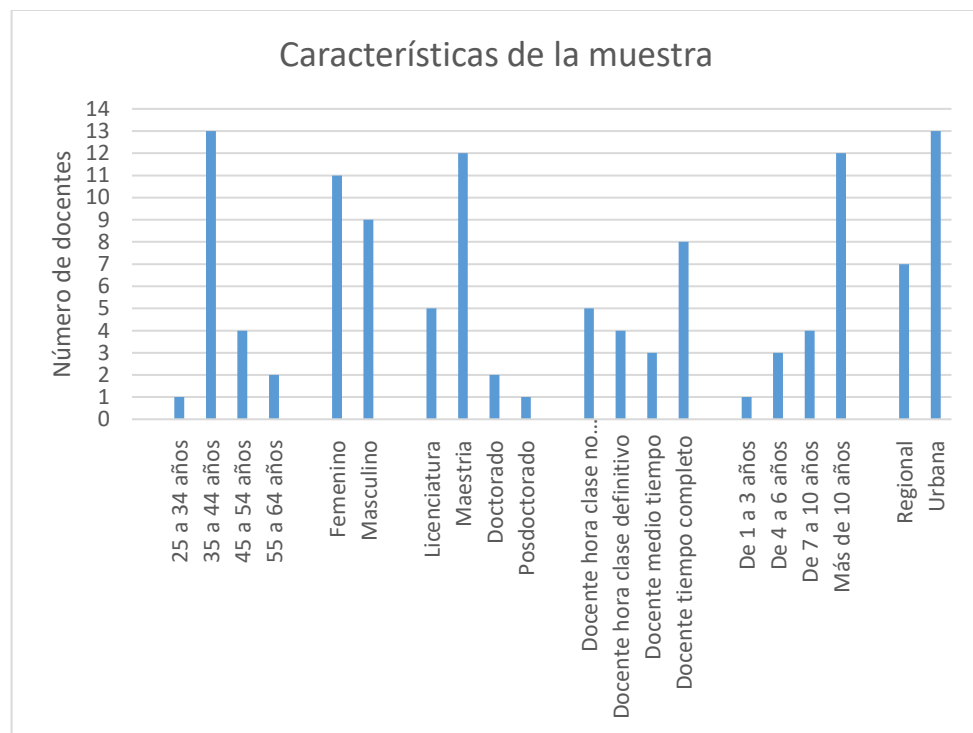


Gráfico 1. Sample characteristics.

Data collection techniques and tools

Most of the data collection took place during the development of TREA, implemented through the Microsoft Teams platform with synchronous sessions guided by a facilitator. These sessions were recorded with prior authorization from the participating teachers, which allowed the collection of evidence of interactions in the sessions, discussions and comments. It was also agreed to record interviews with participants. Another instrument used for data collection was the input, output and follow-up questionnaire, implemented through Microsoft Forms in three moments: the first before starting the workshop, the second at the end of the workshop and the last eight months after the workshop. Finally, there is the registration and protection of the OER prepared by teachers. The diversity and quantity of these materials made it possible to verify the validity of the study by triangulating the information collected.

The systematic review of the literature identified ten factors that intervene for the OER to be incorporated into the teaching practice in an institutional context (García *et al.*, 2021). These factors are explored through the input, output and follow-up questionnaire, which is an adaptation of the OER Readiness Tool-1 survey of the University of Athabasca in Canada, available in its institutional repository. This adaptation was submitted to a validation process by expert judgement (Cabero and Llorente, 2013), based on the congruence index objective item of Rovinelli and Hambleton. A hierarchical order question is used to establish the importance of addressing the identified factors and, due to the options (question type) available in Microsoft Forms, the drag or relocate format was implemented.

Data processing and analysis

Hierarchical questions were processed through a scoring system in which a unique number was assigned to each option. Then the options were ranked by the average, assigning number one to the most relevant factor. The results obtained in the initial survey showed the following order of importance to address the factors listed (see Table 1).

Table 1. Hierarchy of the initial stage factors of PAR

1	Time to find, review and select OER
2	Great diversity of OER
3	Licensing type
4	OER training
5	Personal privacy
6	Technological skills to intervene in OER
7	Recognition or personal labor incentives
8	Use and reuse of the áreas in other courses
9	Institutional repository or library
10	Collaboration teams for OER intervention

In considering this information, the TREA design develops four sequential activities focused on changing the "time to find, review and select OER" factor to a lower hierarchy, which are named below:

- 1) Exploring repositories
- 2) Finding an OER to be reused
- 3) Finding an OER to be adapted
- 4) Find OER to be mixed

RESULTS

One of the preliminary findings of the first TREA activity was that a large number of teachers did not differentiate appropriately between repositories and platforms. A repository is designed to store and organize data, while a platform seeks to offer a specific experience or service, encouraging interaction between users and content. This inaccuracy led to the identification of 37 OER sources that have been recorded in Table 2, which shows the repositories and platforms in this research. The first column lists the resources found during the initial TREA exploration activity. Although many were not used in subsequent activities, as evidenced in the second column, exploration led to discoveries that transcended the areas of mathematics and physics.

Teachers found OER relevant in different areas of knowledge and reflected on the importance of sharing these findings with peers. Consequently, participating teachers were asked to recommend OER sources to their colleagues at two times: at the end of the TREA (third column) and several months later, during follow-up (fourth column). The following details are given in this register:

- The number of repositories is lower compared to platforms.
- OpenStax, Khan Academy and Project Descartes are reported in all observation records of this study.

OpenStax is a non-profit repository based at Rice University that contains an extensive catalog of free college and high school textbooks, written by experts and professionals in each field and peer-reviewed to ensure its quality and accuracy.

Table 2. Record of repositories and platforms identified in the research

REGISTRO DE SITIOS IDENTIFICADOS Y RECOMENDADOS EN LA INVESTIGACIÓN			
EXPLORACIÓN	UTILIZADOS EN EL TREA	RECOMENDADOS	
		SALIDA DEL TREA	SEGUIMIENTO
OpenStax	OpenStax	OpenStax	OpenStax
Khan Academy	Khan Academy	Khan Academy	Khan Academy
Proyecto Descartes	Proyecto Descartes	Proyecto Descartes	Proyecto Descartes
	GeoGebra	GeoGebra	GeoGebra
	Phet Colorado	Phet Colorado	Phet Colorado
	YouTube	YouTube	YouTube
Merlot		Mertlot	Mertlot
		Red Universitaria de Aprendizaje UNAM	Red Universitaria de Aprendizaje UNAM
		Educación-Apple (MX)	Educación-Apple (MX)
Eduteka		Eduteka	
Bidi UNAM		Bidi UNAM	
UNAM-RETo		UNAM-RETo	
Redined		Redined	
Repositorio Colegio de Bachilleres		Repositorio Colegio de Bachilleres	
	OSP Open Source Physics	OSP Open Source Physics	
Curriki	Estadística para todos	European Schoolnet LRES	Arcademics
Intef	Flickr	LiveWorkSheets	Desmos
Mathematics Assessment Project	Math Online Learn Mathematics	Procumun	Edpuzzle
Rincones didácticos	OERCommons	Quizizz	E+ educaplus
Universidad de Guadalajara, Red Universitaria de Jalisco	Universidad Politécnica de Valencia		Colegio de Bachilleres del estado de Sonora
RITEC	Saylor		
	Wikimedia Commons		

In addition to textbooks, it offers a number of supplementary resources, such as study guides, question-and-answer kits and other learning tools. Both Khan Academy and Descartes Digital Educational Network (also known as Project Descartes) are non-profit online educational platforms that provide free access to a variety of learning resources and materials. Both focus on promoting self-directed learning and integrating information and communication technologies (ICTs) into education, with an emphasis on mathematics and science.

- Geogebra, Phet Colorado and YouTube platforms are constantly incorporated into the records of this research, from the activity of finding and reusing an OER to the recommendation stage, months after the conclusion of the TREA.

- The last rows in table 2 at each observation time show repositories or platforms that only appear at that specific time. This observation suggests that teachers are constantly searching for new options to find an OER.

- When teachers were asked to recommend repositories or platforms to find OER, they considered Eduteka, Bidi UNAM, UNAM-RETo, Redined and the repository of the College of Baccalaureates, which although found them in the initial activity, no teacher used them in subsequent TREA activities. The interviews identified that their recommendation was addressed to colleagues in other subjects or educational levels.

- During OER re-use, adaptation and blending, three independent non-profit projects are used. One is Flickr, a specific repository for photographs and videos; another is OER Commons, a collaborative platform promoted by the Institute for the Study of Knowledge Management in Education (ISKME); and, finally, Wikimedia Commons, a media repository that houses content under public domain licenses, such as the GNU Free Documentation License or the Creative Commons Equal Attribution and Sharing License (CC-BY-SA).

- During the exploration phase, the general repository of the Baccalaureate College was identified, generated by the contribution of each state. At the recommendation stage, the content of the section corresponding to the repository of the Colegio de Bachilleres of the state of Sonora is highlighted.

- Arcademics is an online educational gaming platform that uses gamification to enhance students' learning and academic skills. His focus is mainly on the areas of mathematics and language, ranging from kindergarten to high school. On this platform students have the option to play individually, face computer-generated opponents or compete with other students in real time. In order to customize the learning experience and monitor student progress, Arcademics allows teachers and parents to create free accounts.

- Desmos' suggestion is identified as an alternative to GeoGebra because it has a simpler interface, which can facilitate its use for beginners.

According to the methodology established for this research, which includes the initial, intermediate and implementation and evaluation phases, Table 3 shows the change in the hierarchy of the factors at the three observation points contemplated in this study: input, output and tracking. In relation to the central factor of the TREA design "time to find, review and select OER", no changes were observed between the input and output registers, so it remained the most important factor.

However, the results of the monitoring reveal a change, which led to a decline to third position. In interviews, teachers mentioned that the time required to find relevant material has decreased, as they have refined their searches and identified repositories or platforms where they can find the appropriate OER to integrate into their different contexts and content. Although the "find" factor is still relevant, the time teachers spent in this activity lost importance, because during the workshop effective strategies were established to search for OER in repositories and platforms.

It is important to note that the "great diversity of materials" was a factor that remained in the top three at all times of observation and recording. This coincides with the proposal of Khalid *et al.* (2023), who identify the lack of guidelines and standards for the creation of content and formats as a barrier to the implementation of OER.

Table 3. Record of the ranking of factors in the research

Hierarchy of factors		
Entrance	Exit	Follow-up
Time to find, review and select OER	Time to find, review and select OER	Great diversity of OER
Great diversity of OER	Training on OER	Use and reuse of OER in other courses
Type of licensing	Great diversity of OER	Time to find, review and select OER
OER training	Technological skills for OER intervention	OER training
Work privacy	Licensing type	Collaboration teams for OER intervention
Technological skills to intervene in OER	Use and reuse of OER in other courses	Institutional repository or library
Recognition or personal /work incentives	Collaboration teams for OER intervention	Personal privacy
Use and reuse of OER in other courses	Recognition or personal /work incentives	Type of licensing
Institutional repository of library	Institutional repository or library	Technological skills to intervene in OER
Collaboration teams for OER intervention	Personal privacy	Personal/work recognitions or incentives

Another significant aspect of the record shown in table 3 is that factors related to the type of licenses and technological skills were descending in the hierarchy to occupy the last places. According to follow-up interviews, teachers reported that this is because, as they needed to adapt and combine materials, they had to familiarize themselves with the type of licenses and permits associated with each, as well as developing technological skills that allow them to modify materials to suit their specific contexts.

This research also assessed the cyclical model of 5R OER proposed by Wiley (2014) which, as already mentioned, cannot be considered a standard, due to the dynamics that users develop with OER as they integrate them into their teaching practice. By recording the activities that were carried out on the OER and the assessment that the teachers granted them, one of the main discrepancies with respect to the Wiley model was identified (2014): the lack of evidence to support its cyclical nature, as opposed to a linear model in which activities are organized in a hierarchy. This is shown in Table 4 at different times of observation.

Table 4. Record of the ranking of key practices

Ranking of relevance in key OER practices		
Entrance	Exit	Follow-up
Find	Find	Find
Fit	Fit	Fit
Combine and mix	Re-use	Combine and mix
Re-use	Combine and mix	Re-use
Share	Share	Share
Manage	Manage	Manage

DISCUSSION

Some methodological aspects of this study could limit the interpretation of the results obtained. One of these is the use of means analysis for the hierarchy of key factors and practices. Although this approach is useful, limitations may arise when compared with more advanced techniques, such as a diffuse cognitive map that could provide a more detailed analysis, allowing even the identification of the interrelationship in the aspects it analyzes. Another limitation to consider is that this research is based on a small, non-probability and convenience sample, composed of only 20 participants. In addition, it is geographically limited to a single state of the Mexican republic and focuses exclusively on the public sector.

There is also an inherent bias because participants have a specific interest in improving their teaching practices through technological innovation. However, despite these limitations, the study reveals findings that coincide with other investigations, such as those carried out by Baas *et al.* (2019) and Versantvoort and Schuwer (2023). These papers, as in the present study, highlight the fundamental importance of finding REA, although this process may initially be difficult and require a significant investment of time.

On the other hand, the preference identified in this study of teachers for looking for OER in those repositories or platforms that promote the formation of communities agrees with the findings of the study by Drevensek and Urbancic (2022). These communities, which facilitate collaboration and support in activities within the 5R model, strengthen the collaborative aspect of OER. The aforementioned study analyzes how the creation of OER in teams, both local and international, can promote the reuse, remixing and redistribution of these resources.

Figure 2 shows the sequence of key practices during this study, in which OERs are modified (adapted or blended) according to the needs of specific contexts and subsequently reused. This sequence supports student learning according to institutional plans and programs and is consistent with the Versantvoort and Schuwer study (2023), which shows that teachers often mix OER before reusing it. A similar behavior is observed in the research by Van and Katz (2019), which explores the decisions of teachers in training to reuse, mix or create an OER. This specific order of practices approaches, at least empirically, the proposal of renewable tasks of Wiley (2013) and the proposal of pedagogy enabled for the Wiley and Hilton OER (2019).

Another additional aspect to consider in the sequence presented in Figure 2 is the role of managing OER through digital technologies, such as repositories or platforms. For the teachers who participated in the TREA this management seems to be a practice of little relevance. This finding suggests the presence of activities and interactions that may not be

peculiar to teachers, but to other members of the institution, such as librarians. Research supports this idea, highlighting the need for collaboration between academics and administrators (Wang & Wang, 2017; Baas *et al.*, 2019; Stagg & Partridge, 2019; Marín *et al.*, 2022; Versantvoort & Schuwer, 2023). These studies argue for a more active role for libraries or institutional repositories.

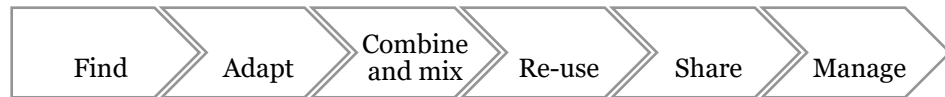


Figure 2. Sequence identified in the research.

A notable example of this integration can be seen in the universities of Salamanca and Pittsburgh, which have managed to give identity and visibility to their OER through their institutional libraries. According to Baas *et al.* (2022), these cases demonstrate how collaboration between teachers and professional teams can strengthen the capacity to adapt, combine or create OER, even contributing to the creation of an institutional image associated with the OER developed by its teachers and students.

In the progress of this study with NMS mathematics and physics teachers, participants considered free textbooks as relevant to their educational work, especially in digital format, as the books available in the OpenStax repository. Although none of the books selected by the participants were reused in full, adaptations were made when extracting and translating specific chapters. This perspective coincides with the study by Redcay *et al.* (2022), who developed and validated a satisfaction scale on the implementation of free textbooks. This research provides a reference point that teachers and authorities can use to facilitate future adjustments to support the adoption of free textbooks at the institutional level.

Other proposals are based on the creation of open guidelines (Open Guidebook Approach, OGA), which seek to resolve the disconnection between teachers and the technological systems used to create and manage interactive books (Kim-mons & Jensen, 2023). Other studies analyze the economic impact on Hispanic students (Leo *et al.*, 2023) and the use of free textbooks as a strategy to improve learning (Franco & Bidarra, 2022). Thus, it highlights the idea that textbooks are still relevant in the teaching-learning process, now incorporating technology.

CONCLUSIONS

Among the most important findings of this study is the need to distinguish the features and functions of repositories and platforms. Despite this challenge, 37 OER sources were identified, highlighting the diversity of options available beyond the areas of mathematics and physics. Participation in these sources allowed teachers to reduce the time required to find materials suitable for their educational practice.

There was a preference among teachers for platforms or repositories that facilitate integration into collaborative teams, highlighting the intrinsic collaborative aspect of OER. This approach enabled teachers to improve their ability to find, review and select OER more efficiently.

The study revealed a difference with the 5R model, in line with other work, where reuse occurs after adaptation and mixing. This order is aligned with specific pedagogical proposals for OER.

The research also highlighted the importance of having professional teams active in libraries and institutional repositories to support teachers to integrate OER into their teaching practice and improve its visibility. Finally, it is reaffirmed that teachers continue to consider free digital textbooks as valuable OER for their teaching practice, which coincides with several proposals for research and innovation in the field.

In summary, the aim of this study was to identify the challenges faced by NMS mathematics and physics teachers in incorporating OER into their teaching practice. The importance of training was recognized to enable them to develop strategies to participate in the 5R model. He also highlighted the crucial role of collaboration and support from professionals, such as librarians, for the integration, visibility and use of OER in teaching practice. Finally, the study highlights the proactive attitude of teachers towards the use and dissemination of OER, in order to improve their pedagogical practices and enrich students' learning.

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(2018). Research design: qualitative, quantitative and mixed methods approaches. SAGE.

Cronin, C. (2017). Openness and Praxis: Exploring the use of open educational practices in higher education. *The International Review of Research in Open and Distributed Learning*, 18(5). <http://dx.doi.org/10.19173/irrodl.v18i5.3096>

Drevensek, M. & Urbancic, T. (2022). The role of teamwork in the creation of open educational resources for closing SDG-related knowledge gaps. *Open Praxis*, 14(2), 148-161. <https://doi.org/10.55982/openpraxis.14.2.266>

Khalid, F.; Wu, M.; Ting, D.; Thoma, B.; Haas, M.; Brenner, M.; Kim, Y. M. & Chan, T. (2023). Guidelines: The Do's, Don'ts and Don't Knows of Creating Open Educational Resources. *Perspectives on Medical Education*, 12(1), 25-40. <https://doi.org/10.5334/pme.817>

Kimmons, R. & Jensen, B. (2023). The Open Guidebook Approach: designs to support collaborative, close-to-practice teacher learning. *Open Praxis*, 15(1), 8-26. <https://doi.org/10.55982/openpraxis.15.1.521>

Franco, D. C. & Bidarra, J. (2022). Instructional design of online courses in Mozambique: The use of ebooks as a strategy to improve learning. *Open Praxis*, 14(2), 122-132. <https://doi.org/10.55982/openpraxis.14.2.141>

García Solano, R.; González Calleros, J. M. y Olmos Pineda, I. (2021). Factores que influyen en la adopción de repositorios de recursos educativos abiertos por parte de los docentes, en D. Mocenchua-Mora, J. Guerrero-García, J. M. González-Calleros, E. Vera-Cervantes y Y. Navarro-Rangel (ed.), *Sistemas y ambientes educativos: experiencias educativas en la covidianidad* (121-138). United Academic Journals. <http://www.dgie.buap.mx/dsae/images/dsae/2021/2021JISAEFinal.pdf>

Geser, G. (2007). Open educational practices and resources. OLCOS Roadmap, 2012. Olcos. <https://eric.ed.gov/?id=ED498433>

Hernández Ávila, C. E. y Carpio Escobar, N. A. (2019). Introducción a los tipos de muestreo. *Alerta, Revista Científica del Instituto Nacional de Salud*, 2(1), 75-79. <https://doi.org/10.5377/alerta.v2i1.7535>

Jhangiani, R. & Biswas-Diener, R. (2017). *Open: The philosophy and practices that are revolutionizing education and science*. Ubiquity Press. <https://doi.org/10.5334/bbc>

Lo, L. S.; Jordan, J. y Surbaugh, H. (2023). El costo del éxito: explorando el impacto de los costos de los libros de texto en una institución R1 que atiende a hispanos. *Open Praxis*, 15(2), 134-148. <https://doi.org/10.55982/openpraxis.15.2.554>

Mallmann, E. M. y Ferreira Nobre, A. M. (2017). Um canal aberto no ensino superior? MOOC e REA no mundo digital. *Apertura*, 9(2), 24-41. <https://doi.org/10.32870/Ap.v9n2.1126>

Marín, V. I.; Zawacki-Richter, O.; Cengiz, H. A.; Bond, M.; Bozkurt, A.; Conrad, D.; Jung, I.; Kondakci, Y.; Prinsloo, P.; Roberts, J.; Veletsianos, G.; Xiao, J. & Zhang, J. (2022). Faculty perceptions, awareness and use of open educational resources for teaching and learning in higher education: a cross-comparative analysis. *Research and Practice in Technology Enhanced Learning*, 17(11). <https://doi.org/10.1186/s41039-022-00185-z>

Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (Unesco). (2020). Anexo VI Recomendación sobre los Recursos Educativos Abiertos (REA). Resoluciones e informes de la Conferencia General en su 40^a reunión. https://unesdoc.unesco.org/ark:/48223/pf0000372579_spa/PDF/372579spa.pdf.multi

Otto, D. (2019). Adoption and Diffusion of Open Educational Resources (OER) in Education: A Meta-Analysis of 25 OER-Projects. *International Review of Research in Open and Distributed Learning*, 20(5), 122-140. <https://doi.org/10.19173/irrodl.v20i5.4472>

Recio Mayorga, J.; Gutiérrez Esteban, P. & Suárez Guerrero, C. (2021). Open Educational Resources in virtual teaching communities. *Apertura*, 13(1), 101-117. <https://doi.org/10.32870/Ap.v13n1.1921>

Redcay, A.; Pfannesntiel, A. N. & Albert, D. (2022). The Development and Validation of the Zero Cost Textbook Satisfaction Scale (ZSS). *Open Praxis*, 14(4), 291-299. <https://doi.org/10.55982/openpraxis.14.4.487>

Schuser, R. & Baas, Y. (2023). Reuse of OER, a Process Model Approach, en D. Otto, G. Scharnberg, M. Kerres & O. ZawackiRichter (eds.), *Distributed Learning Ecosystem* (117-137). Springer. https://doi.org/10.1007/978-3-658-38703-7_7

Stagg, A. & Partidge, H. (2019). Facilitating open access to information: a community approach to open education and open textbooks. *Proceedings of the Association for Information Science and Technology*, 56(1), 477-480. <https://doi.org/10.1002/pras.76>

Tillinghast, B. (2020). Developing an Open Educational Resource and Exploring OER-Enabled Pedagogy. *IAFOR Journal of Education*, 8(2), 159-174. <https://eric.ed.gov/?id=EJ1265738>

Van Allen, J. & Katz, S. (2019). Developing Open Practices in Teacher Education: An Example of Integrating OER and Developing Renewable Assignments. *Open Praxis*, 11(3), 311-319. <https://doi.org/10.5944/openpraxis.11.3.972> Van Allen, J. & Katz, S. (2020). Teaching with OER during pandemics and beyond. *Journal for Multicultural Education*, 14(3), 209- 218. <http://dx.doi.org/10.1108/JME-04-2020-0027>

Versantvoort, M. & Schuwer, R. (2023). Towards Sustainable OER Practices: The Case of Bachelor Nursing in the Netherlands. *Open Praxis*, 15(2), 113-123. <https://doi.org/10.55982/openpraxis.15.2.542>

Wang, S. & Wang, H. (2017). Adoption of open educational resources (OER) textbook for an introductory information systems course. *Open Learning: The*

Journal of Open, Distance and e-Learning, 32(3), 224-235.
<https://doi.org/10.1080/02680513.2017.1354762>

Wiley, D. (2013, October 21). What is open pedagogy? Open Content.
<https://opencontent.org/blog/archives/2975>

Wiley, D. (2014, March 5). The Access Compromise and the 5th R. Open Content.
<http://opencontent.org/blog/archives/3221>

Wiley, D. y Hilton J. (2019). Definiendo la pedagogía habilitada para REA. Revista Mexicana de Bachillerato a Distancia, 11(21).
<https://doi.org/10.22201/cuaed.20074751e.2019.21.68216>



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