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Artículos científicos

Desarrollo de recurso educativo abierto para mejorar la comprensión lectora y la composición de manuscritos científicos: un estudio piloto

Development of an Open Educational Resource to improve reading comprehension and composition of scientific manuscripts: A pilot study

Desenvolvimento de um recurso educacional aberto para melhorar a compreensão de leitura e composição de manuscritos científicos: um estudo piloto

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Resumen

A finales del siglo XX e inicios del XXI, los procesos de aprendizaje se han transformado por el uso de las tecnologías de la información y comunicación (TIC). Por ello, para enfrentar la pandemia ocasionada por el covid-19, las instituciones educativas han tratado de adaptarse mediante la virtualización de las clases. En este sentido, el uso de los recursos educativos abiertos (REA) se ha incrementado por las ventajas que ofrecen. Por ello, el objetivo de este trabajo fue desarrollar un recurso educativo abierto centrado en mejorar la habilidad metacognitiva de estudiantes de posgrado. Para eso, y empleando el modelo ADDIE, se desarrolló el recurso *Buenas prácticas para mejorar la comprensión lectora y composición de manuscritos científicos* (CLEMAC), el cual fue utilizado por siete estudiantes de posgrado de la ESIME Zacatenco, IPN. En concreto, se comparó el promedio general y se observó en los estudiantes una mejora de 5.3 a 7.3 en sus habilidades metacognitivas. Por tanto, los resultados mostraron que CLEMAC es accesible, viable y profundiza habilidades metacognitivas mediante la construcción de actividades que posibilitan el saber y el hacer en torno a la comprensión lectora, escritura de tesis y artículos científicos.

Palabras clave: Sistema de información, diseño instruccional, composición, estrategias didácticas, educación remota.

Abstract

At the end of the 20th century and the beginning of the 21st, learning processes have been transformed by the use of Information and Communication Technologies (ICT). Therefore, to face the pandemic caused by the COVID-19 virus, educational institutions have tried to adapt, through the virtualization of classes. In this sense, the use of Open Educational Resources (OER) has increased due to the advantages they present. Therefore, the objective of this work is to develop an open educational resource that focuses on improving the metacognitive ability of postgraduate students. The resource: Good practices to improve reading comprehension and composition of scientific manuscripts (CLEMAC) was developed using the ADDIE model and was used by seven graduate students from ESIME Zacatenco, IPN. The general average was compared and an improvement from 5.3 to 7.3 in their metacognitive abilities was observed in the students. Therefore, the results showed that CLEMAC is accessible, viable, and deepens metacognitive skills through the construction of activities that enable knowledge and doing around reading comprehension, thesis writing, and scientific articles.

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Keywords: Information system; instructional design; composite; didactic strategies; remote education.

Resumo

No final do século XX e início do XXI, os processos de aprendizagem foram transformados pela utilização das tecnologias de informação e comunicação (TIC). Por isso, para enfrentar a pandemia causada pela covid-19, as instituições de ensino têm tentado se adaptar virtualizando as aulas. Nesse sentido, a utilização de recursos educacionais abertos (REA) tem aumentado pelas vantagens que oferecem. Portanto, o objetivo deste trabalho foi desenvolver um recurso educacional aberto focado na melhoria da capacidade metacognitiva de estudantes de pós-graduação. Para isso, e utilizando o modelo ADDIE, foi desenvolvido o recurso Boas Práticas para Melhorar a Compreensão de Leitura e Composição de Manuscritos Científicos (CLEMAC), que foi utilizado por sete estudantes de pós-graduação da ESIME Zacatenco, IPN. Especificamente, comparou-se a média geral e observou-se uma melhora de 5,3 para 7,3 nas habilidades metacognitivas dos alunos. Portanto, os resultados mostraram que o CLEMAC é acessível, viável e aprofunda habilidades metacognitivas por meio da construção de atividades que possibilitem conhecer e fazer em torno da compreensão de leitura, redação de teses e artigos científicos.

Palavras-chave: Sistema de informação, design instrucional, composição, estratégias de ensino, ensino remoto.

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Introduction

The year 2020 will be remembered for the social isolation generated due to the covid-19 pandemic, which forced educational institutions to implement what they called emergency remote education. This modality represented an abrupt transition from face-to-face teaching to a completely online environment, where learning practices were incorporated into virtual platforms. This new form of education, however, presented significant challenges, such as internet accessibility and the tools necessary to ensure effective connectivity (Green et al., 2020; Tilak and Kumar, 2022; Williamson et al., 2020).

In the specific case of higher education institutions (HEIs), they were entrusted with the task of addressing the problems that arose as a result of covid-19 in relation to the educational

process of students. This adaptation sought to respond to the social, cultural, economic and political demands of the moment with the aim of transforming the way in which students learn and are trained (Martínez-Riera et al., 2018; Rodríguez-Pérez et al., 2021). . To meet these demands, however, there was a need to adapt the academic programs offered by the HEIs so that they were relevant to the circumstances of the moment, which can be determined through various indicators related to academic performance, that is, lag, the failure rate, terminal efficiency and dropout. These allow diagnosing and evaluating the impact of the education provided to students, as well as the effectiveness of educational institutions (Pike and Robbins, 2020; Tucker and McKnight, 2019; Zúñiga-Arrieta and Camacho-Calvo, 2022).

Now, if we focus on terminal efficiency —that is, the number of students enrolled in different programs of an institution, their generation and those who manage to graduate, as long as they have fulfilled all the curricular requirements, completed their thesis or option degree and submitted their degree exam within the deadlines established by the study plans (Álvarez et al., 2012)—we observed an evident decrease in graduation rates (Stincer Gómez *et al*., 2022; Wang *et al*., 2022).

In the case of Mexico, in 2014 terminal efficiency indicators of 41.5%, 33.8% and 27.5% were recorded at the specialty, master's and doctoral levels, respectively (Mexican Council of Postgraduate Studies [COMEPO], 2015). These figures have generated concern in Mexican institutions that offer quality postgraduate programs, since these play a fundamental role in strengthening universities and research centers, as well as in scientific and technological advancement in various disciplines (Cho et al. ., 2021).

One of the factors that influence this situation is related to the metacognitive competencies of students, which cover a wide range of skills with applications in various tasks and contexts. These competencies are highly generalizable and transferable, resulting in effective professional performance (Sá and Serpa, 2018). Therefore, in this study, special attention is paid to reading comprehension and the production of scientific texts as concrete examples of these competencies. To promote terminal efficiency, strategies that encourage self-regulated learning and promote the development of metacognitive competencies that stimulate the production of research and scientific work such as the thesis can be considered (Broadbent and Poon, 2015; Horn et al., 2019).

To address these challenges, it is important to develop and apply open educational resources (OER) that strengthen these skills (Colvard et al., 2018; Xie et al., 2018), since some research has shown that the use of new technologies—such as digital games—can improve

metacognitive skills (Cavalcante-Pimentel et al., 2022). In the case of HEIs, the adoption of OER can boost scientific production, since they are accessible, freely accessible and reliable. This represents a significant advance, especially for those institutions with limited budgets, since a considerable investment in infrastructure is not required to make them available to students and to promote digital literacy (Ochieng and Gyasi, 2021; Ting, 2015).

Furthermore, OER have characteristics that make them ideal for this purpose, since they are free educational resources and materials with open licenses that allow their reproduction, distribution and use for educational purposes on a global level (Henderson et al., 2016; Perifanou and Economides , 2022). These resources are designed to facilitate five fundamental uses: reuse, review, remix, redistribution, and retention (Stracke et al., 2019). Likewise, they allow teachers to save time in preparing materials (Huang et al., 2020) and promote open education and open social learning (Mishra et al., 2022).

Now, for the adoption of OER in the classroom to be effective, it is essential to consider three essential dimensions (Marín et al., 2022). Firstly, the personal dimension involves establishing the objectives of their use, how they will be integrated with existing knowledge and how they will contribute to the enrichment of knowledge (Mtebe and Raisamo, 2014), which can be very useful for facilitators at the time of incorporate them into your teaching practice. Secondly, the dimension of norms, laws and standards is essential for the creation and use of OER, since it is essential to respect copyright and comply with quality criteria in its development (Cox and Trotter, 2016). In this dimension are instructional designers and facilitators. Finally, the institutional dimension encompasses educational institutions interested in the adoption of OER, since they must consider the necessary infrastructure, implementation strategies and support mechanisms for its use and creation. (Cox y Trotter, 2016).

On the other hand, the United Nations Educational, Scientific and Cultural Organization (UNESCO) recommends the development, access, use, adaptation and redistribution of this type of resources in nations. This must be in line with support policies that include care for their quality with the aim of being inclusive and equitable to foster sustainability models and promote international cooperation (Unesco, 2019).

Regarding the methodologies for creating these resources, the instructional design stands out, understood as a set of integrated elements that pursue a defined objective. This is characterized by being interdependent —since its value lies in the content that is intended to be transmitted— and cybernetic —since it is supported by technology and computer systems— (Gazca-Herrera, 2021; Wisneski et al., 2015). Furthermore, it incorporates pedagogical and

design aspects that are integrated into a system of procedures to develop educational content and training programs in a coherent and reliable manner (Caliskan, 2014; Meyer et al., 2017; Wang et al., 2021).

Having explained the above, it can be indicated that the objective of this research was to design, build, implement and evaluate the open educational resource (OER) called Good practices to improve reading comprehension and the composition of scientific manuscripts (CLEMAC). To this end, it was assumed that OER represent a viable alternative to support the development of metacognitive skills, in particular, those related to the understanding of research texts, the search for information, and the structure and writing of scientific texts. fundamental skills to promote the development of scientific works and, therefore, contribute to improving terminal efficiency in postgraduate programs.

Materials and methods

Study design

This research was exploratory (Hernández-Sampieri et al., 2014), as it focused on a topic little examined at the postgraduate level. The unit of analysis was the Postgraduate Studies and Research Section of the ESIME Zacatenco of the National Polytechnic Institute. To do this, a pilot sample of seven students participated, of which two were from the doctoral level (one from the last semester and one from the first) and five from the master's level (three from the second and two from the fourth semester). The inclusion criteria were accessibility to participate in the study and the proximity of the subjects to the researcher. (Otzen y Manterola, 2017).

Design and construction of the REA based on the ADDIE model

To carry out the design, construction, implementation and evaluation of the OER, the stages of the ADDIE model were used, that is, analysis (Draper et al., 2018), design (Dong, 2021), development (York et al., 2016), implementation and evaluation. In the analysis stage, the qualitative documentary approach recommended by Johnson and Vindrola (2017) was used; For this purpose, scientific and popular databases were searched with the keywords postgraduate, text composition, reading comprehension and information search.

In addition, a consultation was carried out with practical experts through the coordinator of the graduate program in which the study was carried out (Checkland, 1993) and a diagnosis was made on the academic and research performance, which involved students and graduates. of

the postgraduate degree in Systems Engineering through the electronic survey method (Páramo, 2017), using the GEDACA platform (Aviles-Yañez et al., 2022). This is a relational database and uses an open source language called PHP (Hypertext Preprocessor) to extract and relate information from students' academic background and educational environment.

Then, the results obtained from the three aforementioned procedures were synthesized, analyzed and merged in order to identify the critical aspects, both positive and negative, of the educational system under study (Domínguez-Hernández et al., 2017). This made it possible to define the objectives of the open educational resource (OER), as well as the user profile, the topics to be addressed, the type of evaluations and the framework for its implementation.

For the design and development of the OER, the guidelines established by Hameed et al. were followed. (2019), according to the standards and objectives of the learning unit that was sought to impact. In this case, the results of the three procedures carried out in the analysis stage were integrated. In addition, the structure of the thesis document used in the Systems Engineering postgraduate course and the IMRYD format of a scientific research article were reviewed. This was done to define the expected learning objectives and how they would be implemented in the resource using graphical and textual elements.

In the structure of the learning activities, several important criteria were considered, such as which thematic block they corresponded to, the learning context in which they would be carried out, the type of activity, the formation of groups, the necessary resources, the system of evaluation, the role of the teacher and the duration of the activities.

In the implementation and evaluation stages, the planning, application and evaluation of the open educational resource (OER) was carried out through the course Good practices to improve reading comprehension and composition of scientific manuscripts in postgraduate studies (CLEMAC). Due to the prevailing health emergency, it was decided that the course would be carried out online. To access the course, users needed to have a computer or a mobile device with internet access.

To disseminate the OER, the coordination of the Master of Science in Systems Engineering sent personalized invitations to students via email. The objective was to encourage them to participate in the course and apply what they learned directly in the preparation of their theses. The invitation included a link to connect via Teams, as well as the session schedule, dates, times, and teaching materials. Furthermore, as a strategy, participants were asked to provide their thesis work so that improvements could be addressed based on the planned topics.

The course application was carried out through videoconferences through Teams. The dynamics of each session followed a similar pattern. It began with the presentation of the task assigned in the previous meeting, which was voluntary on the part of the participants. Due to time constraints, only a maximum of five interventions of three minutes each were allowed. The instructor would then address the topic scheduled for that session for approximately an hour, using slides and videos to reinforce the concepts. Subsequently, a space was opened for questions or doubts about the reviewed topic. Once this process was completed, participants worked on an assigned activity that reflected the knowledge acquired in the session, and later presented their results. Finally, the farewell took place (table 1).

Table 1. Example of the session program of the CLEMAC resource

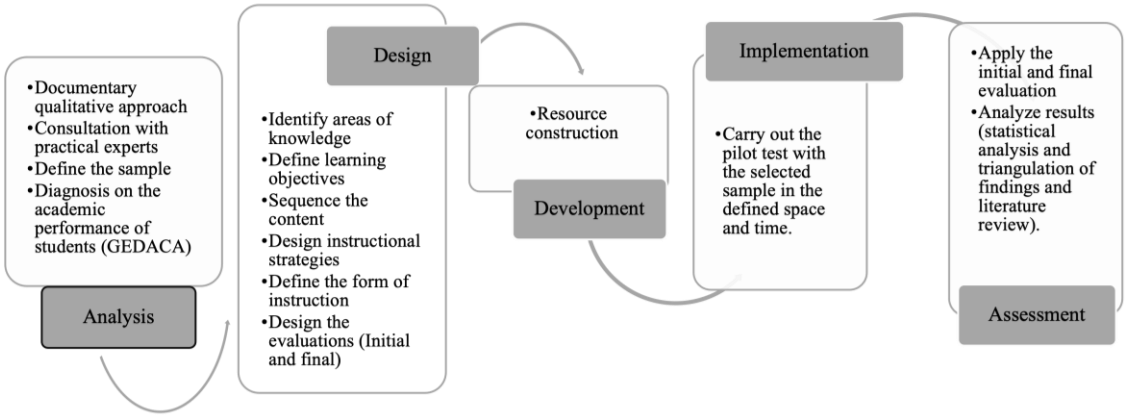
Activity	Duration	Responsible
Presentation of activity 2	3 minutes per participant Maximum 5 participants 15-20 minutes	Participants and instructor
Topic: Discriminate information, specialized databases and references in APA format	50 minutes	Instructor
Tips for using different databases	10 minutes	Instructor
Question session	5 minutes	instructor and participants
Activity 2	15 minutes	Participants
Presentation of activity results	4 minutes per participant Maximum 5 20 minutes	Instructor and participants
Farewell	5 minutes	Instructor

Source: Self made

The evaluation of learning is a key piece in the design of OER (Leyva et al., 2018; Umaña-Mata et al., 2017). For this reason, two evaluation instruments were generated: the first was diagnostic, which was applied at the beginning to determine prior knowledge about the topics reviewed. The questions were generic and multiple choice. The second test was applied in the last session to measure the knowledge achieved with the resource. The questions were oriented to the specific topics that were reviewed. Each instrument was made up of 20 items, with their respective feedback. For this, the Google Forms office tool was used, as it has questionnaires and surveys that allow data to be collected in a simple way (Leyva et al., 2018).

Statistical analysis was performed using graphical and tabular methods using the Excel tool. The variables analyzed were search for scientific information, reading comprehension and composition of scientific manuscripts. For the validity of the study, a triangulation was made between the findings and the literature review following the recommendation of Stake (2020), and Aguilar-Gavira and Barroso-Osuna (2015). Figure 1 reflects the methodological flow that guided this study.

Figure 1. Applied methodological flow



Source: Self made

Results

Analysis

The consultation with theoretical and practical experts, as well as the diagnosis of academic and research performance with students through GEDACA (Aviles-Yañez et al., 2022) indicated the following (table 2).

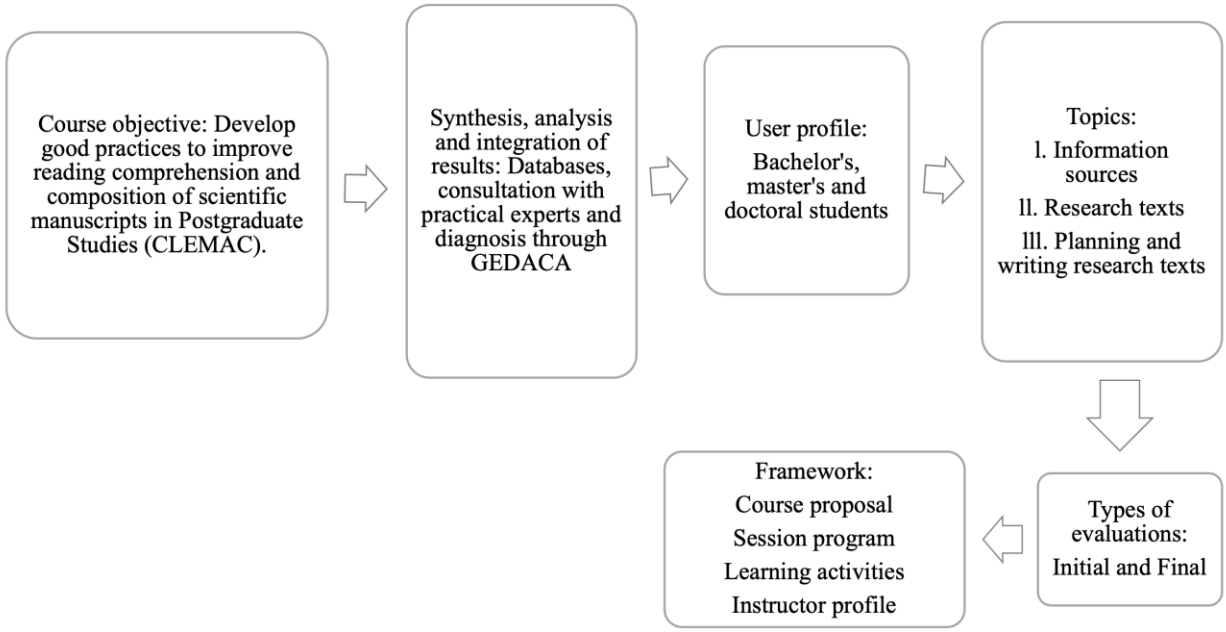
Table 2. Results of the research instruments

Consultation with theoretical/practical experts and GEDACA	Results
Analyzed dimensions: Academic backgrounds Academic performance	These instruments yielded the following: 1. Postgraduate students do not know and/or do not fully know the importance and use of scientific, dissemination and statistical information databases recognized by the scientific community. 2. They present difficulty in the process of searching and discriminating information to implement it in specific contexts, 3. There are weaknesses in identifying the structure and composition of scientific texts such as thesis work.

Source: Self made

Therefore, the objective of the CLEMAC REA, the user profile, the course topics and their distribution, the types and moments of the evaluations, and the framework for its application were defined (figure 2).

Figure 2. Description of the analysis results for the REA



Source: Self made

Design and development

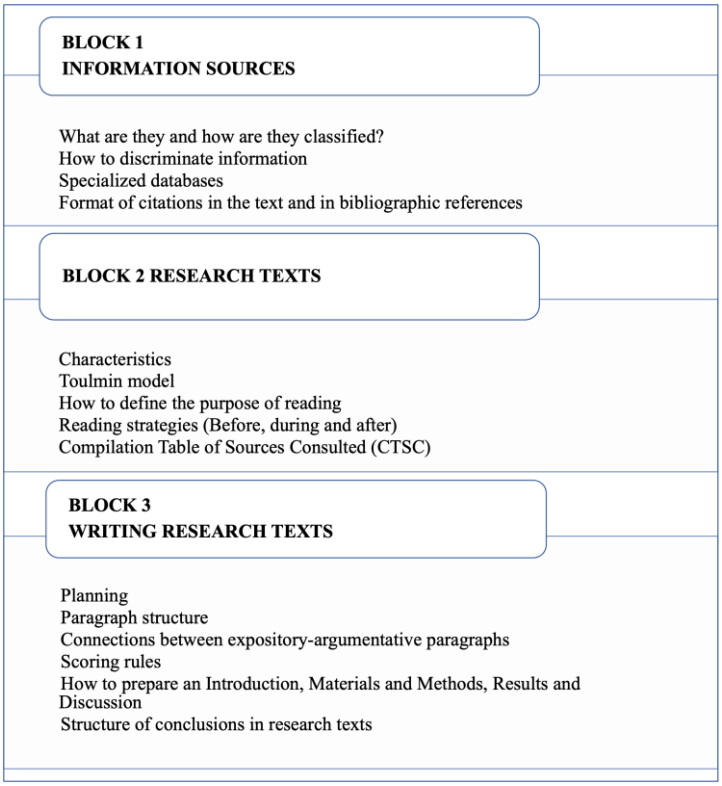
By integrating the results of the analysis, three objectives were defined, for which their approach was described in content blocks of the CLEMAC OER:

1. Ability of students to identify, access and use databases specialized in scientific, dissemination and statistical information in different fields of knowledge. To this end, sessions were designed where topics oriented to sources of information were reviewed, that is, what they are, where to find them and how to make their respective references. In this way, the aim was for the student to develop the ability to search for relevant information and define their research problem with a transdisciplinary systemic approach by searching for information with key words.
2. Recognize the main characteristics of research texts and define what type of text the product of your research should be. For this, sessions were designed aimed at identifying the main characteristics of the research texts, as well as the structure of the argumentation applying the Toulmin model, that is, defining the purpose of reading and the strategies for reading comprehension, and how to organize information to through the source compilation table (CTSC).
3. Structure a research text in an appropriate and relevant way, through the review of topics related to the planning and structure of paragraphs, the connections between expository-argumentative paragraphs, as well as punctuation rules. Likewise, how to write an introduction, materials and methods, results and discussion, and recommendations for writing research texts.

Likewise, guiding questions were formulated to help participants diagnose their research problem. Likewise, efforts were made to work directly and in parallel on the corrections of their research, according to the topics reviewed.

The application of the course was 100% virtual through the use of various technological resources, such as the Teams platform, since it is suitable for generating collaborative work spaces where participants can meet, share documents, plan and collaborate with each other (Giraldo-Ospina, 2021). Each virtual class lasted three hours due to the sanitary conditions caused by the covid-19 pandemic. As a consequence of the nature of the topics, the course was divided into three blocks organized into nine sessions, each with its program and times for the theoretical and practical parts, as well as those responsible for the activities, the form of delivery, the necessary materials and the feedback time (figure 3).

Figure 3. Content blocks of the CLEMAC REA



Source: Self made

The CLEMAC technological structure covers the minimum requirements in order to respect the guidelines established by the CUDI (Edel et al., 2021), such as usability, since the technological tool was sought to be user-friendly. For this reason, it was built in a slide format for the presentation of content through Power Point. Likewise, nine presentations were created to relate each of the topics described in the manual. The interface design was simple so that the user had clarity and precision when consulting the content. The development of each topic was planned independently without losing sight of its relationship with the competencies linked to metacognition. In order to give greater dynamism, diagrams and images were used (table 3).

Table 3. Distribution of slides by topic

Block	Number of session	Topics	Number of slides
l. Information sources	1	-What they are and how they are classified	16
	2	-Discriminate information -Specialized databases -Specialized databases	18
2. Research texts	3	-Characteristics -Toulmin model	18
	4	- How to define the purpose of reading -Reading strategies (before and during)	12
	5	--Reading strategies (after reading) -Compilation table of consulted sources (CTSC)	8
3. Writing research texts	6	- Planning - Paragraph structure	41
	7	- Connections between expository-argumentative paragraphs - Scoring rules	32
	8	- How to prepare an introduction, materials and methods, results and discussion - Structure of conclusions in research texts	16
	9	-Structure of conclusions in research texts	19
Total slides			180

Source: Self made

Guiding questions, comparison tables, questionnaires for reading comprehension and analysis of scientific texts were used as teaching strategies. In total, 10 activities were designed: two for block I, three for block 2, six for block 3, and email was used to deliver the activities to the participants.

The resource was made available remotely in Teams so that users could access it through their institutional or personal account. The display of content and graphics was dynamic and motivating, for which colors and shapes that attracted attention were used. Likewise, multimedia resources were used, such as videos and images in accordance with their profile. The teaching

material was shared via email: slides, articles to explain the analysis of research texts and three YouTube videos with an open access license.

By addressing the reusability of the resource, it was designed for all types of high school and higher education users who want to improve their metacognitive skills such as reading comprehension, analysis and composition of research texts. The importance of the content lies in the fact that the daily situations and experiences of students in their educational practice were addressed.

Implementation and evaluation

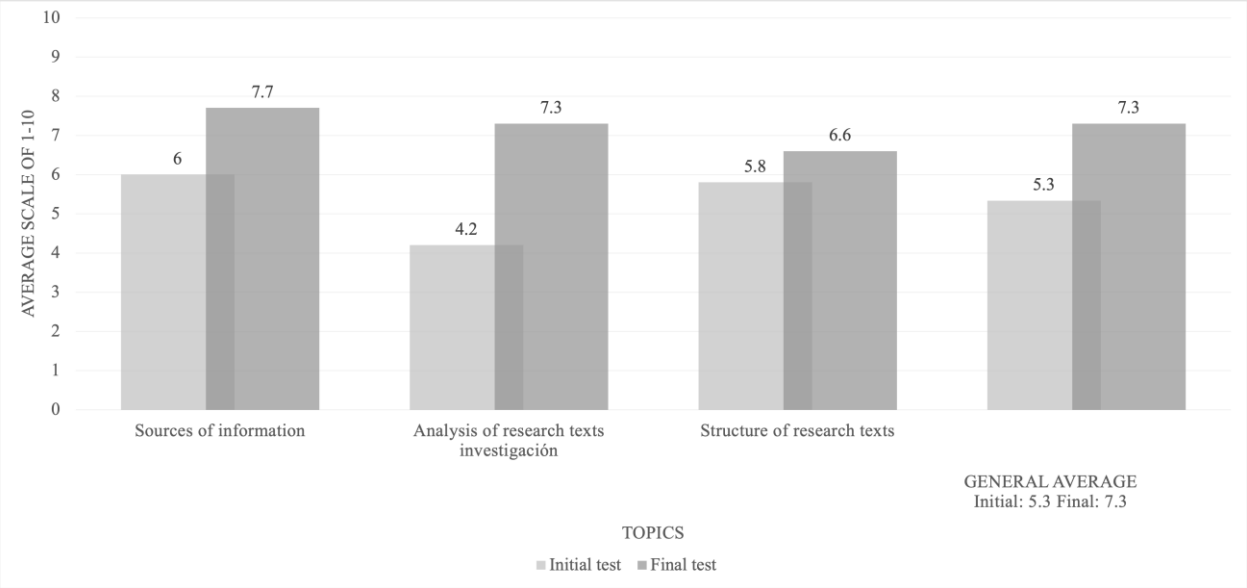
The invitation to the course was made by email, which indicated the name of the workshop, the objective, the topics, the dates, the times, the platform used and who the instructors were. Likewise, it was indicated that the course modality was online through the Teams platform and it was indicated what the minimum requirements were to access the course; In this case, have computer equipment connected to the Internet and have your thesis work available. The guests and attendees of the course were students of the master's degree and doctorate in Systems Engineering Sciences (MCIS) from the Postgraduate Studies and Research Section (SEPI) of the ESIME Zacatenco of the National Polytechnic Institute.

Regarding the evaluations, two were applied: one initial and one final. Each was made up of 20 multiple-choice items that covered the following topics: sources of information, research texts, and planning and writing research texts. Google Forms was chosen for its administration.

In the initial evaluation, the general average of skills of the group of students was 5.3, on a scale of 1 to 10, distributed as follows: in information sources they reached 6, which shows that greater emphasis is required on specific search of specialized databases and how to discriminate information. Regarding the analysis of the texts, an average of 4.2 (lowest category) was obtained, which indicates that reading comprehension must be strengthened through techniques that help improve this cognitive skill. In relation to the structure of texts, an average of 5.8 was found, which indicates that, although they know the required structure, they still find it difficult to compose.

Now, in the final evaluation, significant advances were found in terms of text analysis (they went from 4.2 to 7.3), sources of information (from 6.0 to 7.7) and structure of research texts (from 5.8 to 6.6). This demonstrates a general progress in the skills addressed, since it went from a total average of 5.3 to 7.3 (figure 4).

Figure 4. Comparison of results between the initial and final evaluation of the group of graduate students



Source: Self made

Discussion

The results of the review with theoretical experts indicate that studies related to the use of OER to improve reading comprehension and composition of scientific manuscripts at the postgraduate level are limited, since no other resources aimed at postgraduate students pursuing this goal were found. end, which shows that this work can be a reference for other investigations. Therefore, the findings show that it is essential to define an instructional design that methodically helps to achieve each task pursued by this type of educational resources.

On the other hand, the application of the ADDIE methodology demonstrated that in the analysis stage it is essential to carry out the qualitative documentary approach, the consultation with practical experts and the diagnosis of needs to determine which aspects affect the situation in which it seeks to influence. In this case, some of the factors detected had to do with the adequate preparation of the thesis work and the metacognitive competencies linked to reading comprehension, discrimination of information and the composition of research texts.

These skills are essential to facilitate the process of composing the thesis work (Domínguez-Hernández et al., 2017; Horn, 2019; Johnson and Vindrola, 2017; Páramo, 2017; Xie, 2018). Therefore, it is essential that various actions be integrated that help determine the

study situation (Checkland, 1993). Likewise, the profile of the users was defined, which in this case was for any student who had to compose scientific texts at the higher level.

In the design and development stage, it is important to consider the dimensions on which you want to impact (e.g., institutional) (Mtebe and Raisamo, 2014). Therefore, this resource was based on the document of the Postgraduate Research Secretariat 30 (SIP 30) to establish the guidelines for the structure of the thesis. Accessibility and usability were covered through the digital educational platform Teams, for which care was taken to ensure that the graphic interface of the Power Point presentations was pleasant, intuitive and effective.

The reusability of the resource was comprehensively addressed, as technological tools and an approach were designed to adapt to a wide spectrum of potential users, that is, university-level students interested in improving the metacognitive competencies outlined in the resource. Therefore, it can be stated that the standards proposed by CUDI were met. (Edel *et al*., 2021).

For the design and development, an instructional methodology was used that defined in detail the elements of each session, including the teaching material, the structure and type of learning activities, the evaluations, the resources, the instructors, and the duration of the instruction. This approach follows recommendations from experts in the field (Caliskan, 2014; Gazca-Herrera, 2021; Meyer et al., 2017; Wang et al., 2021; Wisneski et al., 2015).

Regarding implementation and evaluation, various aspects were considered, such as the technological requirements of Teams, the duration of the presentations, the participation of instructors, the methods of inviting participants, and the schedule of sessions. In the evaluation, two types were applied: initial (exploratory) and final (summative). The results indicate that prior knowledge was explored and progress was made in the development of the skills in question, with a usefulness index of 2.7%. Therefore, it is concluded that the design and construction of the CLEMAC OER, despite being a pilot study, represents a viable alternative to support the development of metacognitive skills, especially in areas such as reading comprehension, information search, structure and writing. of research texts, all essential to promote the preparation of degree works.

Conclusions

The main objective of this research was to conceive, develop, implement and evaluate the CLEMAC REA. Despite being a pilot study, the results obtained demonstrate that this resource represents a solid alternative to promote the development of metacognitive skills, particularly those related to understanding research texts, searching for information, structuring and writing. of scientific documents. These skills are essential to promote the development of degree work and, therefore, contribute to progress in the field of knowledge. Furthermore, this work could benefit significantly from being validated and applied in different populations.

Even so, it is recommended to take into account aspects of accessibility, usability and reusability, as well as consider both technological and pedagogical standards (Marcelo et al., 2014). In addition, attention must be paid to the institutional aspect, since educational institutions that wish to develop this type of resources must consider the necessary infrastructure, strategies for their adoption and support mechanisms for their implementation and creation. It is also crucial to foster effective collaboration between instructional designers and teachers to ensure that resources not only meet the technological aspects, but also enrich the pedagogical aspect to ensure that educational objectives are achieved. Finally, the use of intelligent learning environments that adapt to the individual and group needs of students should be promoted. (Rodríguez-Ramírez y Zepeda-Bautista, 2022).

Future lines of research

Undoubtedly, the use of technology-mediated resources in the educational field offers numerous advantages. Therefore, future lines of research can focus on areas such as neurolearning in relation to instructional design and open educational resources. Likewise, transdisciplinarity between neuroscience, hybrid education and emergency education can be explored with the aim of improving fundamental skills such as reading comprehension and the production of scientific texts. Another promising area could be data mining applied to emerging disciplines such as neuroscience and neurolearning, which would represent a significant advance in the field of knowledge by providing valuable information on the advances and advantages that these disciplines offer to address deficiencies in the learning process that was accentuated during the covid-19 pandemic.

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