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Design and implementation of a digital textbook about physical agents as a learning resource in the training process of Chilean physical therapy students in the context of the COVID-19 pandemic

Running title: **Digital textbook as a learning resource in the COVID-19 pandemic.**

Diseño e implementación de un libro de texto digital sobre agentes físicos como recurso de aprendizaje en la formación de estudiantes chilenos de fisioterapia en el contexto de la pandemia por COVID-19.

Título corto: **Libro de texto digital como recurso de aprendizaje en la pandemia por COVID-19.**

Aceptado: Revisado

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Abstract

The COVID-19 pandemic has had a strong impact on education, forcing the implementation of distance learning methodologies using information and communication technologies (ICT).

The digital textbook is a didactic resource used to guide the training process of students; besides, its interactivity allows systematic work, favoring metacognition and the construction of self-learning.

The aim of this paper is to describe, through a descriptive cross-sectional design, the design, review, digitalization and implementation phases of a digital textbook about physical agents as a learning resource to support distance education in the training process of physical therapy students enrolled in the physical agents course offered by Universidad Andres Bello in Santiago, Chile, in the context of the human mobility restriction measures implemented due to the COVID-19 pandemic.

The textbook consists of thirteen thematic sections and once it was reviewed and validated by peers and by the editorial committee of the university it was digitalized and indexed into the digital resource database of the university, where it was made available to the entire cohort of students enrolled in the physical agents course during the first semester of 2020 (n=115).The digital textbook was successfully implemented as a didactic resource to guide the autonomous and distance learning of students during the time human mobility restriction measures were established in

Chile due to the pandemic. Future studies should focus on reporting the students' satisfaction and perception of this tool and its effect on learning outcomes in order to obtain effective feedback.

Keywords: Books; Textbook; Distance Learning; Information Technology; Students; Physiotherapy; Physical Therapy Specialty; COVID-19 (MeSH).

de la Barra-Ortiz, Gómez-Miranda LA. Design and implementation of a digital textbook about physical agents as a learning resource in the training process of Chilean physical therapy students in the context of the COVID-19 pandemic. Rev. Fac. Med. 2022;70(4):e94683 (In Press). English. doi: https://doi.org/10.15446/revfacmed.v70n4.94683.

Resumen

La pandemia por COVID-19 ha tenido un fuerte impacto en la educación, por lo que ha sido necesario implementar metodologías de aprendizaje a distancia basadas en tecnologías de la información y las comunicaciones (TIC).

El libro de texto digital es un recurso didáctico utilizado para guiar el proceso de formación de los estudiantes; además, su interactividad permite el trabajo sistemático, lo que favorece la metacognición y construcción del aprendizaje autónomo.

El objetivo de este estudio es describir, mediante un diseño transversal descriptivo, las fases de diseño, revisión, digitalización e implementación de un libro de texto digital sobre agentes físicos como recurso de aprendizaje para apoyar la educación a distancia en el proceso de formación de en estudiantes de Fisioterapia inscritos en el curso de agentes físicos

ofrecido por la Universidad Andres Bello en Santiago, Chile, en el contexto de las medidas de restricción de movilidad humana implementadas por la pandemia por COVID-19.

El libro de texto consiste de 13 secciones temáticas y una vez revisado y validado por pares y por el comité editorial de la universidad, fue digitalizado e indexado en la base de datos de recursos digitales de la universidad, donde se puso a disposición de toda la cohorte de estudiantes matriculados en el curso durante el primer semestre de 2020 (n=115).

El libro de texto digital se implementó satisfactoriamente como recurso didáctico para guiar el aprendizaje autónomo y no presencial de los estudiantes en el periodo que se instauraron las medidas de restricción de la movilidad humana en Chile debido a la pandemia. Estudios futuros deben centrarse en reportar la satisfacción y percepción de los estudiantes con esta herramienta y su efecto en los resultados del aprendizaje para obtener una retroalimentación efectiva.

Palabras clave: Libros; Libro de texto; Educación a distancia; Tecnología de la Información; Estudiantes del área de la salud; Fisioterapia (DeCS).

de la Barra-Ortiz, Gómez-Miranda LA. [Diseño e implementación de un libro de texto digital sobre agentes físicos como recurso de aprendizaje en la formación de estudiantes chilenos de fisioterapia en el contexto de la pandemia por COVID-19]. Rev. Fac. Med. 2022;70(4):e94683 (In Press). English. doi: https://doi.org/10.15446/revfacmed.v70n4.94683.

INTRODUCTION

Education is undergoing a scientific and technological transformation brought about by globalization, a phenomenon that has mightily influenced and fostered change in higher education institutions. (1). Given its role in social policies and the development of countries, education is the engine of social mobility and a key factor to overcome poverty and address inequality (2,3). The United Nations Educational, Scientific and Cultural Organization (UNESCO) World Conference on Higher Education identified the challenges and pivotal roles of higher education in our global knowledge society, as well as certain key traits, such as social responsibility; access, equity, and quality; internationalization, regionalization and globalization; and learning, research and innovation, all of which are essential to generate high-quality, inclusive, equitable education and to foster permanent learning opportunities for everybody. This is not a lesser challenge, especially in the context of a pandemic, and it addresses the fourth sustainable development goal (SDG) (4-6).

On the other hand, professional training is currently undergoing a series of transformations that incorporate various teaching formats, ranging from face-to-face to blended learning to fully online learning modes, which implies the combination of learning facilitators to attain the targeted quality (7,8).

Activities and resources of the face-to-face and online modes are integrated in varying proportions to achieve the learning outcomes (LO) of a course, with greater efficiency, quality and adaptability (7,9,10), thus championing a predominantly constructivist learning approach, since learners restructure their knowledge. By means of this process, new information is processed and learned (11-13). This approach focuses on students as key

stakeholders since it makes them responsible for their own training process, yet it does not relegate the instructor's guidance and systematic feedback (10,12,14). Thus, self-learning is a need to be addressed in the training process. This need has forced many higher-learning institutions to adapt their learning, research, and social processes so as to align them with the use of information and communication technologies (ICTs) (15-17).

COVID-19 and distance learning

The Coronavirus (COVID-19) has spread rapidly around the world after the first case was detected in China in December 2019 (18). UNESCO has assessed the impact of the coronavirus on education: schools and universities have been closed in 116 countries as of March 30, 2020, and the closures have had an impact on 87% of the world's student population, which amounts to 1,520 million (19).

The global health crisis has forced the educational world to develop remote pedagogical strategies (20). In this modality, teaching is regarded as two-way communication that replaces personal interaction in the classroom. Various didactic resources are used in conjunction with tutorial support, which favors autonomous student learning (21). Although content storage and interaction channels are different, the current pedagogical bases may be reinforced by favoring the principle of interactivity or socialization (21,22). Three advantages of distance learning stand out: access to the perks of educational technology, the possibility of avoiding time-space limitations, and the feasibility of doing teamwork, regardless of spatial or chronological differences. This learning model can have a positive impact on the students' cognitive and constructivist development by providing

them with the power to choose their best learning opportunities and having the instructor guide them in this process (23).

Among the recommendations made by UNESCO to higher-education institutions, the postponement of face-to-face academic activities, academic meetings and congresses stand out, which has forced universities to close their facilities. To safeguard teaching, the use of ICTs by learning institutions has been promoted through online platforms or virtual campuses to facilitate distance learning, which has required online training and support for both instructors and students (18,24).

Self-learning

Self-learning is a didactic and pedagogical strategy that effectively addresses professional training needs, and it fosters the students' development of skills and core competencies (25-27). It is the individual learning style of each person, who manages his own learning and moves forward by looking up information. This pedagogical strategy enables people to "learn how to learn" by making them more aware of their cognitive process, developing knowledge about their mental processes, and making them think about how we learn (26,28).

Self-learning becomes real when students are able to think critically and reflexively for themselves. This conceptualization requires that faculty members develop pedagogical practices that include significant learning situations, encourage problem-solving in different professional contexts (29-31), and foster critical thinking through argumentation and the development of oral and written communication skills suitable to the academic and professional fields (32,34). The development of the students' self-learning ability demands versatility in the teaching strategies em-

ployed if students are to understand the subject matter in the same way as experts do in each discipline (27). Therefore, didactic strategies must be selected with the students' needs, interests, and skills in mind in order to guarantee their learning (35-38).

The role of information and communication technologies

ICTs allow us to combine digital information, which means it is possible to mix text with images, videos, and sounds. This capability turns them into yet another alternative for learning and self-study, all of which is possible thanks to the development of Internet-based communications (39-41).

ICTs play a pivotal role in learning, especially in blended or distance-learning modalities in the context of a pandemic, and they have been embraced for their potential to promote self-learning, highlighting the association between the senses and learning (42,43). This is particularly observable in more interactive ICTs, in which students, together with receiving the information, must carry out activities (43,44), use different technological and communication tools, as well as tools and channels for accessing and exchanging information (45). Nowadays, they can access these resources from different devices and from anywhere in the world, which facilitates interconnectivity (40).

Consequently, the ICTs promote students' active roles and modify learning by shifting the teaching focus to a model focused on learning, thus following the traits of the constructivist model (46). According to UNESCO, the ICTs contribute to a universal access to education, equality, and quality teaching and learning; and they facilitate the spread of information, improve quality and guarantee integration, which are essential elements in times of a pandemic and the implementation of confinement and human

mobility restriction measures (47).

Textbook

Didactic materials are any element or instrument used for teaching and learning, including printed, audiovisual, or multimedia resources that are used to facilitate the process (48). The use of these materials contributes to the building of knowledge by providing clearer meanings of concepts (49). Among all teaching materials, the textbook remains a learning tool that is broadly used by teaching staff and students (49). A textbook is "a structured, printed material intended to be used in a specific learning and training process," and it includes the information that students need to demonstrate knowledge in a specific subject (50). They are also regarded as vehicles of knowledge and information that one generation wishes to transmit to the next (50).

Among the advantages of the textbook as a learning resource, the guarantee of equal learning opportunities for students stands out since it is a resource available to all, making knowledge accessible at all times of the training process (47-50). In general, physiotherapy students prefer the digital format due to their convenience (50). Furthermore, this resource allows the instructor to identify students who experience limitations when performing various activities, it can be a resource for academic information, and a source of tasks, exercises, and assessment activities (48,49). Some textbooks include self-study practice sheets intended to enhance discovery learning by articulating intellectual and research work techniques, as well as individual and group activities (50).

As the training of health professionals involves the development of comprehension and analytical skills, the digital textbook—given its charac-

teristics—is a didactic option that can be added and adapted to various professional training programs (46-48).

Physical agents

Physical agents are therapeutic resources that physiotherapists often use in rehabilitation processes to relieve pain, reduce edema, control alterations in muscle tone, promote tissue repair and increase strength, or to augment the effectiveness of other interventions aimed at solving mobility problems and facilitating functional restoration. They are broadly used in undergraduate physiotherapy programs (51,52). The use of physical agents requires a good understanding of their biophysics, knowledge of their indications, precautions and contraindications, as well as the skills involved in their application, so it is essential to develop analytical and evaluative skills when applying these therapeutic modalities to guarantee their safe use and, thus, attain better clinical results (53-60).

The acquisition of analytical and reasoning skills by in-training physical therapists and their use of physical agents have become challenges in the context of the pandemic. These skills require that students understand physiological concepts, contraindications, precautions, and indications when using these resources so that their use in different clinical contexts is firmly grounded. For this reason, the digital textbook was the resource of choice to develop these skills and learning outcomes and to integrate the knowledge related to this subject. Taking this into account, the objective of this paper is to describe, through a descriptive cross-sectional design, the design, review, digitalization and implementation phases of a digital textbook about physical agents as a learning resource to support distance education in the training process of physical therapy students

enrolled in the physical agents course offered by Universidad Andres Bello in Santiago, Chile, in the context of the human mobility restriction measures implemented due to the COVID-19 pandemic.

DESIGN AND IMPLEMENTATION OF DIGITAL TEXTBOOK ON PHYSICAL AGENTS

According to the institutional model of the Universidad Andrés Bello, all courses use active methodologies and are oriented to the achievement of learning outcomes. The physical agents course is offered to fourth year Physical Therapy students. The course consists of three face-to-face teaching hours and six hours of autonomous work per week during 16 weeks (5 Standard Credit Transfer System - SCTS credits). In the COVID-19 pandemic context and due to the confinement and human mobility restriction measures implemented in Chile, the physical agents course was developed entirely for the online mode, meeting weekly for three pedagogical hours of synchronous work and six asynchronous hours of autonomous work for 16 weeks (5 SCTS).

The creation of the digital textbook was proposed as a guide for the asynchronous activities on the grounds of its accessibility, potential to reduce inequality in knowledge and to reinforce content through weekly activities.

The digital textbook was implemented as a didactic resource to support distance education of fourth year physical therapy students enrolled in the physical agents during the first semester of 2020 (March to July).

The elaboration of the digital textbook involved four stages: design, review, digitization, and implementation.

Design of digital textbook

The design stage was consisted of structuring the thematic units and the accompanying activities. Thirteen units were developed using the contents of the course program and their respective LO as guides (61). The digital textbook was structured so as to attain LO 1 and LO 2 specified in the program and linked to the analytic and evaluative skills with regard to different physical agents modalities (TABLE 1). LO 3 was not included due to its procedural nature.

TABLE 1. Learning outcomes of physical agents course program and thematic contents of the textbook.

LEARNING OUTCOMES	DESCRIPTION	THEMATIC UNITS
LO 1	To analyze the physical and physiological effects of using non-ionizing Physical Agents.	1. Physical Agents overview 2. Pain: Physiological aspects and Neuromodulation with Physical Agents 3. Electrotherapy: Physics and overview of electric modalities 4. Biphasic pulsed current (BPC) 5. Medium-frequency currents: Interferential and Russian 6. Electromagnetic spectrum 7. Phototherapy 8. Short wave diathermy 9. Ultrasound 10. Hydrotherapy 11. Superficial thermotherapy 12. Cryotherapy
LO 2	To assess the use of different non-ionizing Physical Agents in line with the target therapeutic effect in various professional contexts with the goal of addressing deficiencies and problems in the patients' functioning as a result of various health conditions.	
LO 3	To evaluate the deficiencies and functional problems derived from users health conditions, as well as the relevance and context of intervention trough non-ionizing physical agents.	

Source: own elaboration based on the data obtained in the study.

Each thematic unit of the digital textbook was structured in two parts: a summary and worksheets (TABLE 2) (61). The summary consisted of a general description of each topic, highlighting the key concepts of the content discussed, as well as the contraindications and risks of each physical agents. The worksheet section consisted of a variety of strategies, such as definitions, multiple-choice questions, interpretation and analysis of images, and development of clinical cases. The summary and the worksheets were increasingly complex to match the cognitive levels of LO to achieve, at the end of each unit, the analytical and evaluative skills associated with the topic of each section (61).

Finally, the thirteenth section of the digital textbook (answer key) included the solutions to problems and answers for all the evaluative components, thus providing feedback to students at the end of each activity.

TABLE 2. Sections and activities of digital textbook.

THEMATIC UNIT	SUMMARY	DEFINITIONS	CLASSIFICATION CHARTS	ESSAY QUESTIONS	MULTIPLE-CHOICE QUESTIONS	EXPLANATION OF IMAGES	CALCULATIONS	CLINICAL CASES
1. Physical agents overview	√	√	√	-	√	√	-	√
2. Pain: Physiological aspects and Neuromodulation	√	√	√	-	√	√	-	√
3. Electrotherapy: Physics and overview of electric modalities	√	√	√	√	-	√	√	√
4. Biphasic pulsed current	√	√	-	√	√	√	√	√
5. Medium-frequency currents: Interferential and Russian	√	√	-	√	√	√	-	√
6. Electromagnetic spectrum	√	√	√	-	√	√	√	
7. Phototherapy	√	√	-	√	√	√	√	√
8. Short wave diathermy	√	√	-	√	√	√	√	√
9. Ultrasound	√	√	-	√	√	√	√	√
10. Hydrotherapy	√	√	-	√	√	√	-	√
11. Superficial thermotherapy	√	√	-	√	√	√	-	-
12. Cryotherapy	√	√	-	√	√	√	-	-
13. Problem solving	√	√	√	√	√	√	√	√

Source: own elaboration based on the data obtained in the study.

√: Activity included in the unit

-: Activity not included in the unit

Review of the digital textbook

This phase consisted on review of contents led by the course coordinator to guarantee that there was coherence between the topics and their activities. A second review was conducted by peers for content validation, as well as the relationship between the contents and the LO specified in the course program. A third review was performed by the university editorial board.

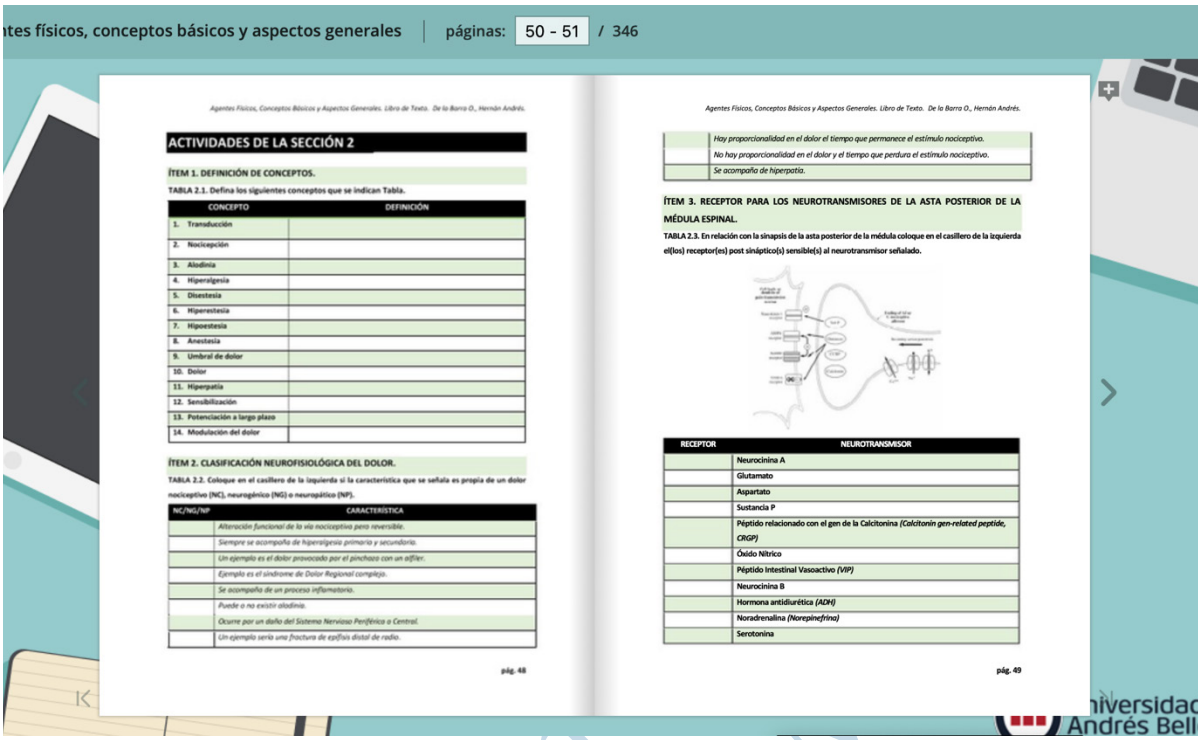
Digitalization of the digital textbook

The book digitization stage was undertaken by the institution's library department. The book was digitized and later uploaded to the university's digital resources platform to guarantee student access to the material (62) (FIGURE 1,2 and 3). After the digitization was completed, the intellectual property of the work was registered (63).

FIGURE 1. Digital textbook about Physical Agents as an electronic learning resource.

Source: Own elaboration.

FIGURE 2. Activities of the digital textbook.



Source: Own elaboration.

Implementation of digital textbook

Once the textbook was reviewed and validated by peers and by the editorial committee of the University, it was digitalized and indexed into the digital resource database of the university, where it was made available to all the students enrolled during the first semester of 2020 in the physical agents course (n=115).

Then, at the start of the course the textbook was presented to all students as a digital learning resource and they were informed how they could access it: the textbook was available at http://recursosdigitales.unab.cl/rdigital/index.php) and in order to access it they needed to enter their institutional credentials (example: name@uandresbello.edu and personal password),. An induction session was carried out explaining the content

of the book and its use during the course for asynchronous autonomous activities. The digital textbook was successfully implemented and introduced to the students as the course's self-study resource. Students were exposed to weekly readings and activities with feedback.

To evaluate the preliminary results of the use of the digital textbook as a support learning tool for asynchronous activities, as a support resource for distance education in the training process of Physical Therapy students, a multiple-choice test was carried out according to defined learning outcomes and digital textbook content. A test-retest analysis of three sections of the textbook (1, 2, 4) was performed. The test was carried out prior to the asynchronous autonomous activity, and the re-test after this activity.

Preliminary results

Statistical analysis was performed with STATA software, version 13.0. The scores obtained for the entire cohort at each evaluation (test and retest) were analyzed using the Shapiro-Wilk normality test to determine the distribution and to define the statistical procedures and descriptive statistics to be used (64). Scores were described using measures of central tendency (medians) and measures of dispersion (interquartile ranges). Test-retest scores were then compared using the U-Mann Whitney test; a significance level of $p<0.05$ was considered.

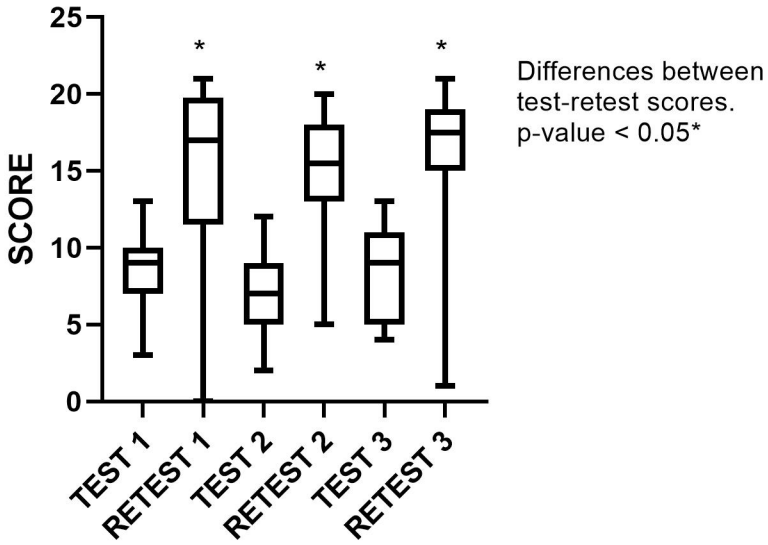
Scores data showed a non-normal distribution for all evaluations except for re-test 2, so scores are presented using medians with its corresponding interquartile ranges (IQR), representing the data dispersion between the 25th and 75th percentile (P25-P75) (TABLE 3). Preliminary results show a significant increase in scores between the test and the retest for the LO of three thematic sections of the textbook that were evaluated.

TABLE 3. Digital Textbook test-retest scores

THEMATIC UNIT	DIGITAL TEXBOOK SECTION	EVALUATION	SCORE DISTRIBUTION**	P-VALUE	MEDIAN	(P_{25}-P_{75})	MINIMUM SCORE	MAXIMUM SCORE	RANK	DIFFERENCES BETWEEN TEST AND RETEST SCORES***
Physical agents overview	1	TEST 1	NON-NORMAL	0.0245*	9	(7-10)	3	13	10	<0.0001*
		RETEST 1	NON-NORMAL	<0.0001*	17	(11,5-19,5)	0	21	21	
Pain: Physiological aspects and Neuromodulation	2	TEST 2	NORMAL	0.1782	7	(5-9)	2	12	10	<0.0001*
		RETEST 2	NON-NORMAL	0.0036*	15,5	(13-18)	5	20	15	
Biphasic pulsed current	4	TEST 3	NON-NORMAL	0.0036*	9	(5-11)	4	13	9	<0.0001*
		RETEST 3	NON-NORMAL	<0.0001*	17,5	(15-21)	1	21	20	

Source: own elaboration based on the data obtained in the study.
(*) p – value <0.05
(**) Normality analysis performed through the Shapiro Wilk test.
(***) Difference between medians analysis performed trough the U-Mann Whitney test.

Figure 3. Evaluation of LO for sections of digital textbook.



Source: Own elaboration.

CONCLUSION

Digital textbooks are widely used didactic resources in education. On the other hand, distance learning is found more frequently at different levels of training as evidenced by the transition of various academic programs from face-to-face to online or blended modalities in the context of a pandemic (65-67).

Distance learning also makes it possible to dismiss the time and space limitations, ensuring access to more sources of information and allowing the addition of multimedia resources that facilitate the transmission of content, all of which reinforces the principle of interactivity or socialization (40). Distance learning optimizes the students' training since it strengthens their self-learning and bolsters the process and self-learning is a key element of distance learning and one of the goals of the training of a professional (66,67).

The objective of this work was to describe the design and implementation of a digital textbook as a learning resource for Physical Therapy students, enrolled in the physical agents course, in order to support their distance learning and reinforce two of the course's essential LO to, subsequently, further their clinical skills.

Preliminary results of the implementation of the digital textbook suggest that it contributed to the acquisition of LOs by the students enrolled in the physical agents course during the first semester of 2020.

The choice of this resource was grounded on the need to provide educational equity by offering essential information together with systematic work. Thus, a didactic product was developed by mixing the learning benefits of a textbook and ICT, which are part of our daily lives (15,16). Many advantages of digital textbooks have been described, including their flexibility, adaptability, interactivity, customizability, self-assessment, and ease of understanding, all of which give this resource much value (43,66).

One of the great challenges of physical agents training is attaining solid theoretical knowledge to support clinical practice (60,61). Additionally, a transversal disadvantage of the courses is that it is not easy to assess the students' actual workload, which sometimes leads to an underestimation or overestimation of their work (67). Consequently, the digital textbook is a good learning choice because its assessment components are presented in increasing complexity in terms of cognitive levels in line with the activities of the various units. In addition, there is an emphasis on weekly learning activities in order to evenly distribute the students' workload. Furthermore, the material has a feedback unit on the activities, which is complemented by the discussion of the issues with the instructor (68).

The COVID-19 pandemic forced the closure of institutions, affecting worldwide education and training processes (68-70). The replacement of face-to-face instruction with virtual classrooms can be seen as a learning and development opportunity for teaching staff in the sphere of ICT, although virtual teaching may be restricted by the level of technological maturity of the institutions and the availability of technological resources for those involved in this experience, which conditions the quality of the process (68, 69).

Distance learning forces instructors to rethink their traditional teaching methodologies and reevaluate them in terms of their coherence and adaptability to the new format. This transformation opens a space for the development of creative thinking based on innovative methodologies that facilitate the students' LO (67,70,71).

The digital textbook is a valuable learning tool to guide distance learning and to contextualize learning activities. In this work, the textbook was implemented as a learning strategy for the physical agents course in the Physiotherapy program, and its implementation was successfully in the COVID-19 pandemic context in order to improve LOs achievement. It implied the adjustment of didactic procedures and it provided a guiding light for the distance learning activities. The next stage is to wait for the ripening of the material and to update and enhance the self-study sections, the evaluation of the student satisfaction level and the impact on the learning outcomes, which will permit the continuous improvement of the healthcare professionals' training in online and face to face modalities.

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