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Methodology for the management of learning objects in the Physics discipline

Metodología para la gestión de los objetos de aprendizaje en la disciplina Física

Metodologia para gerenciamento de objetos de aprendizagem na disciplina de Física

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ABSTRACT
The introduction of learning objects in the educational field, especially in universities, constitutes new challenges for teachers, researchers and students as it allows the use of more complete didactic resources for the teaching-learning process in any of the modalities of learning studies. This article; The objective was to propose a methodology for the management of learning objects for the teaching of Physics in the Agronomy career under the dialectical materialist conception and the use of methods using the analysis-synthesis, induction-deduction, documentary analysis methods, survey, as well as the determination of dimensions. The selected population was made up of first- and second-year students (78) of the Agronomy major at the University of Pinar del Río during the 2021-2022 academic year, professors from the Physics department and members of the Educational Technology Group. The methodology, is supported from the Educational Sciences, provides the steps to follow the object until its conservation and socialization. Contains two components; the first conceptual theoretical with an objective and foundations that support it and the second instrumental with four stages, each one with actions to be carried out. The results obtained allow us to improve the teaching process that is carried out in keeping with current times and established educational policies, encouraging both teachers and students to acquire the necessary skills and abilities to solve the proposed activities, to which is added collaborative work and share knowledge through virtual environments.

Keywords: learning objects; learning object management; higher education; repository; digital resources.

RESUMEN
La introducción de los objetos de aprendizaje en el ámbito educativo, en especial en las Universidades, constituye nuevos desafíos para profesores, investigadores y estudiantes, en tanto permite la utilización de recursos didácticos más completos para el proceso de enseñanza-aprendizaje en cualquiera de las modalidades de estudios. El presente artículo tuvo como objetivo proponer una metodología para la gestión de los objetos de aprendizaje para la enseñanza de Física en la carrera de Agronomía, bajo la concepción dialéctico-materialista y la utilización de los métodos: análisis-

síntesis, inducción-deducción, el análisis documental, encuesta, así como la determinación de dimensiones. La población seleccionada estuvo integrada por los estudiantes de primero y segundo año de la carrera de Agronomía en la Universidad de Pinar del Río "Hermanos Saíz Montes de Oca" durante el curso 2021-2022, profesores del departamento de Física e integrantes del Grupo de Tecnología Educativa. La metodología está sustentada desde las Ciencias de la Educación y brinda los pasos a seguir del objeto hasta su conservación y socialización. Contiene dos componentes: el primero, teórico-conceptual, con un objetivo y fundamentos que lo sustentan y el segundo, instrumental, con cuatro etapas, cada una con acciones a ejecutar. Los resultados obtenidos permiten perfeccionar el proceso de enseñanza que se desarrolla, a tono con los momentos actuales y las políticas educativas establecidas, propiciando que, tanto docentes como estudiantes, adquieran competencias y habilidades necesarias para resolver las actividades propuestas; a ello se le suma el trabajo colaborativo y compartir el conocimiento a través de los entornos virtuales.

Palabras clave: objetos de aprendizaje; gestión de objetos de aprendizaje; Educación Superior; repositorio; recursos digitales.

RESUMO
As universities, we constitute not you As universidades, constituem novos desafios para professores, pesquisadores e estudantes, pois permite a utilização de recursos didáticos mais completos para o processo de ensino-aprendizagem em qualquer uma das modalidades de estudo. O objetivo deste artigo foi propor uma metodologia de gerenciamento de objetos de aprendizagem para o ensino de Física no curso de Agronomia, sob a concepção dialético-materialista e a utilização dos métodos: análise-síntese, indução-dedução, análise documental, levantamento, bem como a determinação de dimensões. A população selecionada foi composta por alunos do primeiro e segundo ano do curso de Agronomia da Universidade de Pinar del Río "Hermanos Saíz Montes de Oca" durante o ano letivo 2021-2022, professores do departamento de Física e membros do Grupo de Tecnologia Educacional. A metodologia é apoiada pelas Ciências da Educação e fornece os passos a seguir desde o objeto até à sua conservação e socialização. Contém dois componentes: o primeiro, teórico-conceitual, com objetivo e fundamentos que o sustentam e o segundo, instrumental, com quatro etapas, cada uma com ações a serem executadas. Os resultados obtidos permitem-nos aperfeiçoar o processo de ensino que se desenvolve, em consonância com os momentos atuais e ases políticas educativas estabelecidas, garantindo que tanto professores como alunos adquiram as competências e habilidades necessárias à resolução das atividades propostas; Soma-se a isso o trabalho colaborativo e o compartilhamento de conhecimento por meio de ambientes virtuais.

Palavras-chave: objetos de aprendizagem; gerenciamento de objetos de aprendizagem; Educação superior; repositório; recursos digitais.

INTRODUCTION

The advances in Information and Communications Technologies (ICT) have gained great strength in recent years in the education sector, generating a variety of educational resources in virtual environments and enabling new ways to teach, learn and access knowledge. for both teachers and students.

Among these resources are Learning Objects (LO), with emphasis on universities in the teaching process. Its insertion, as proposed by (Maldonado Mahauad , 2017), enables the generation of reusable educational content that can be integrated

and deployed in different technological environments.

The term OA is not new, there are countless and broad definitions provided and some authors consider that it is related to the object-oriented programming model in the 60s, which involves the integration of an object in other programs such as: text, the images, the buttons.

The lack of consensus in its conceptualization has led to the use of multiple synonymous terms: *learning object* , reusable learning objects, reusable knowledge object, knowledge capsule (Martínez Naharro *et al.* , 2008).

One of the main theorists and promoters of the concept of learning object (Wiley, 2000) states that it is "any digital resource that can be reused as a support for learning", giving great importance to the reuse of the object and that it can be adapted in any way . around.

Research related to LOs alludes to authors who have raised several assumptions about the term without eliminating its essence, emphasizing the pedagogical context, accessibility, reusability, interoperability in virtual environments, storage in repositories or digital libraries and metadata.

Mahauad stands out when considering LOs as:

> …independent digital teaching unit, whose structure is made up of a learning objective, content, a set of activities and a self-assessment. It can be reused in different technological (Repositories of Virtual Teaching and Learning Environments) and educational contexts, and it also has metadata that facilitates its location within repositories and allows its contextualization to be addressed (2017, p. 10).

According to Aguilar Juárez *et al.* refer to LOs as units of teaching material that have the purpose of being reusable in various learning sequences, they are characterized by using standards to be defined according to their theme, file format, learning level among other characteristics, in such a way that its storage and retrieval in learning object repositories is facilitated (Aguilar Juárez *et al.*, 2020, p. 58).

Interesting is the criterion that understands them as digital, independent, reusable, interactive, durable, easily accessible entities, which contain an objective, content, a learning activity, metadata and an evaluation mechanism, supported by technology; designed to be used in teaching and learning processes, with the aim of generating knowledge, skills, attitudes and competencies based on the needs of the student, oriented on an online learning platform, whose support format must be suitable for incorporation into said spaces (Alvarado Melitón & Berra Mondragón, 2022).

In one way or another, studies point to OA as a digital or non-digital resource; didactic units with a structure, content, objective, evaluation and educational character. These have the characteristic of being accessible in any virtual environment, for which metadata is important for their use, accessibility and recovery, as well as the possibility of being reusable.

Cuban education is not immune to the changes that are introduced in the teaching-learning process favored by ICT and from the very conception of the country. In its economic model, guidelines and strategies are applied that lead to the strengthening of the elevation of educational quality and the generation of resources and content of digital information, which responds to articles 146 and 147 (PCC, 2000) of the Resolution on the Guidelines of the Economic and Social Policy of the Party and the Revolution.

The Ministry of Higher Education (MES) establishes strategic lines related to the insertion of ICT in training programs. In turn, it has ruled on different actions in relation to educational technology, among which are: the implementation of educational technology laboratories, the development of repositories of learning objects from the Resource Centers for Learning and Research.

Regarding the application of OA and its insertion into the teaching process, different researchers from Cuban universities: Nueva *et al.* (2022), Hernández-Domínguez *et al.* (2022), Alonso Reyes *et al.* (2017), Tamayo-Cuenca *et al.* (2018), to mention a few, have made their contributions based on proposed use, methodology, evaluation indicators among other elements, and are currently still in studies.

However, according to Colome (2019), in his study he provides that there is no single model where parameters are established for the creation of an LO, each university has adopted a methodology for its design and use.

In Higher Education in Pinar del Río, there are initiatives by teachers and students in the development and use of technological educational resources that have an approach to learning objects. In this aspect, the disciplines of basic sciences mainly stand out and, within them, the discipline of Physics.

The teaching of Physics, at the "Hermano Saíz Montes de Oca" headquarters of the University of Pinar del Río, is taught in the training of engineers in the careers of: Industrial, Telecommunications, Computer Science, Agronomy, Forestry and Geology; all of which is based on the understanding of the phenomena, laws and principles that occur in the soil, plants, animals, climate, as well as their interaction with agricultural machinery, where mechanical, gravitational, molecular processes are evident. electromagnetic, atomic and nuclear, which are present in the most complex forms of the movement of matter and, in particular, biological movement.

Specifically, in the Agronomy major, the development of virtual laboratories, simulations and educational software in the Physics discipline stands out, where teachers and students have made use of them. However, its management has not been ideal, since it has not responded to a university policy in this regard or to the standards for its development or has not even taken into consideration the particularities of the discipline itself and the career for development. or reuse of these resources.

The above allowed us to identify a group of manifestations that led to the development of the research such as:

- Virtual laboratories, simulations and other resources used in the PEA during the teaching of Physics. These are downloaded from the Internet with prior authorization from their authors and included on the institution's FTP site, which implies that only in some cases changes can be made to them that adjust to the student's training needs and educational level.
- The construction of didactic resources for the teaching-learning process for the discipline of Physics does not correspond to the potential that ICT and training in virtual environments offer us.
- Access to teaching resources is insufficient, since information is normally transferred from portable device (memory) to portable device.

Based on these manifestations, the author carried out a preliminary exploratory study in which documentary analysis, interviews with teachers, managers, students, as well as observation of students in the development of the independent study were used, in which the following manifestations were confirmed. :

Strengths

- Teachers with more than 30 years of professional experience committed to social responsibility and the use of teaching resources.
- Teachers and students with skills in the use of ICT.
- Existence of digital teaching materials that can be used as learning objects.
- Development of virtual laboratories and simulations by teachers and students.

Weaknesses

- Lack of knowledge on the part of teachers of the structure for creating LOs, as well as the inclusion of metadata in them.
- Insufficient mastery in the management of OA from tools for its development and socialization. Insufficient mastery of the evaluation of the quality of the LOs for their use in the process.

In addition, document analysis of the subject programs was carried out; The use of Information and Communications Technologies stands out as strengths that are taken into account, but it is not always exploited in a systematic and integrated manner.

In observing the students, it was found that they do not always use digital resources to support their self-learning and difficulties are evident in relation to the management of information in the different existing ones at the University and on the Internet.

Taking into account the above, the objective of the research was to propose a methodology for the management of learning objects in the Physics discipline of the University of Pinar del Río "Hermanos Saíz Montes de Oca " .

MATERIALS AND METHODS

The research was developed under the general dialectical-materialist methodological approach, making it possible to operate with its laws, categories and principles, using research methods of theoretical, empirical and statistical levels that properly combined show qualitative and quantitative elements.

Among the **theoretical level** methods, the following were used: the historical-logical analysis method, which allowed us to delve into the evolution and trends of LOs in the international and national context, as well as characteristics and regularities for the teaching-learning of Physics in the training of the Agricultural Engineer at the University of Pinar del Río "Hermanos Saíz Montes de Oca".

The analysis-synthesis made it possible to determine the essential aspects of the learning object management process, decomposing it into its parts and qualities for theoretical analysis, which will be unified taking into account those common elements, which makes it possible to understand its structure and subsequently model it.

The induction-deduction method allowed us to analyze the theoretical sources and basic contents of the LOs.

Empirical level methods

Document analysis: allowed establishing and clarifying categories or theoretical-conceptual elements of the learning object management process based on the bibliographic review, as well as governing documents of the policy of the Ministry of Higher Education and the Directorate of Educational Technology on the computerization.

Survey: allowed us to know how teachers and students create and manage LOs; as well as its level of use and current development in the discipline of Physics in the Agronomy degree.

Interview: was applied to specialists who are members of the Educational Technology Group, with the objective of obtaining information about the current and future state of LOs from the institution.

The selected population was made up of 176 students of the Agronomy major, for which inclusion and exclusion criteria were applied.

Inclusion criteria: first and second year students; and exclusion criteria are those with more than 30% absences, for a sample of 78 students during the 2021-2022 academic year.

Regarding the teachers, those teachers who do not teach Physics were excluded, and as an inclusion, teachers with the main category of Full, Auxiliary and Assistant categories; teachers with master's degrees. The above determined the existence of 13 professors from the Physics department, all university graduates, with degrees in education, eight professors, for 61.54%, and five graduates from non-pedagogical careers, for 38.46%; Of them, five are doctors, for 38.46%, eight are master's degrees, for 61.53%, four are tenured (30.77%), three are assistants (30.77%) and five are assistants (38.46%).). 100% of the total worked in the teaching process with the aforementioned educational resources.

In the selection of the members of the technology group, six were selected out of 10, as they were the ones who were actively developing actions on educational technology issues from the training of distance education.

In the formation of the methodology, three dimensions were determined: technological, pedagogical and administrative.

Technological dimension: LOs are digital resources or units that cover technological aspects treated in the teaching of Physics. These must generate motivation and interest in students, to encourage work with it and thus promote learning. As a digital resource, it must comply with certain attributes that make it attractive and dynamic, such as the appropriate use of colors, fonts, presentation and arrangement of information, navigability, among others. Likewise, the requirement for standards will facilitate the exchange between various systems and platforms, as well as reuse and scalability in educational environments.

Among the main characteristics we can mention: reusability, interoperability, accessibility, portability, flexibility and granularity, among others. The dimension implies the technological infrastructure to support the LOs in the Institutional Repository or in the Digital Library.

Pedagogical dimension: the LOs have an educational intention, which allowed establishing logical sequences for the effectiveness of the teaching-learning process, harmonizing with the technological and administrative dimensions depending on the objectives pursued in terms of creation, conservation (storage) and socialization of learning objects, which requires technological infrastructure to support it, as well as the administration process that is generated for its correct implementation and accessibility.

Administrative dimension: related to the way in which the LOs are hosted in the environments and provide navigation tools for their management. The dimension included elements that the teacher had to follow when planning his class and determine the LO, once created, based on the appropriate software, which will allow them to be reused in other contexts.

RESULTS

The results of the survey of first and second year students of the Agronomy major showed the poor development that the students have in terms of the existing resources in the University network (7.69%); 72% of students use resources such as simulations, interactive guides and virtual laboratories in a way guided by the teacher and, when reviewing these resources, they require integration with other tools to make them become OA.

In the interviews with the professors of the Physics Department it was possible to recognize that:

- 69.23% of teachers consider that students in the first and second year still have low mastery in the use of Information and Communications Technologies and the management of the resources available on the intranet of the University of Pinar del Río " Saíz Montes de Oca Brothers ." Emphasis is placed on the preparation of students in terms of information management, not only on the intranet but also on the Internet.
- 69.23% of teachers use educational resources (interactive guides) in the teaching-learning process, with favorable results.
- 100% of teachers show extensive command and use of email and chat; However, most of them state that they do not have sufficient knowledge to handle other communication tools.
- The results show that 100% of teachers prepare educational resources through the LARBIUD tool, software designed specifically for teaching Physics.
- The results show that 100% of the teachers have not received training actions in other tools (EXeLearning , Author) for the design of LO, if they use the MOODLE platform for teaching Physics.

Regarding the interview carried out with the members of the educational technology group, they all agree that there is no general national policy regarding the production of OA; However, each university has adopted requirements and develops its resources.

Teachers who teach Physics apply a unique tool for this teaching that helps students learn, but it should be completed with tools such as eXeLearning, which can be managed and reused in other contexts.

Regarding the model that is proposed, the interviewees consider that it is an action within the strategy that is implemented at the University: Information, Informatization and Communication (I2+C), related to the development of media, which must be made effective not only for the teaching of Physics, but for the rest of the teachings at the University.

Proposal for a methodology for the management of learning objects in the Physics discipline of the University of Pinar del Río

The term methodology has been addressed by different authors interchangeably [Álvarez de Zayas y Sierra (Álvarez de Zayas & Sierra Lombardía, s. f.)] they consider it "as a science aimed at certain processes in an efficient and effective manner to achieve the desired results optimally"

Valle (2007) considers that methodology refers to how to do something, to the establishment of ways, methods and procedures to achieve an end; In it, the contents are taken into account to achieve a specific objective.

Other authors such as Alfonso Easy *et al.* (2011) assume that it is a system of methods, procedures and techniques that, regulated by certain requirements, allow us to better organize thinking and the mode of action to obtain certain cognitive purposes.

In this sense, the definition offered by the researchers is assumed, taking into account that, with a systemic nature, methods, procedures and techniques are used in a logical process in which stages, links or conditioning steps are followed and concatenated among themselves that, at the same time, being ordered in a particular and flexible way, they allow obtaining the proposed scientific knowledge.

The development of a methodology presupposes the design and management to preserve learning objects for teaching Physics in repositories and, in this way, transform the study activity with technological means.

The methodology in question for the management of LOs with its components contributes to digitizing and making accessible the knowledge acquired, allowing its versatile treatment and rapid dissemination.

From the theoretical component, the methodology aims to: intentionally and consciously guide the teacher on the management of learning objects for teaching Physics in the Agronomy degree.

It is based on the theoretical assumptions of the Educational Sciences that, with a philosophical approach, explain the physical phenomena, object of study in the teaching of Physics of the Agronomy career that, for various reasons, do not admit experimentation and are presented taking into account its form, structure and content, following the laws and categories themselves, making it possible to expand students' knowledge, which contributes to the reasoning of thought from the abstract to the concrete.

The interrelationship is established between the learning object and the subject that participates in the teaching-learning process, so a relationship between student-student, student-teacher, student-medium-teacher is produced.

At the same time, the methodology acts as a socializing agent that starts from the individual level in which knowledge is externalized to transmit values and attitudes; where both the teacher who teaches Physics, the student who receives the knowledge and the specialist who helps in the administration process of the management of learning objects have specific functions that, executed as a holistic system, allow transforming the reality.

The author of this work agrees with Blanco Pérez (1997) when stating how "the relationship between society and education can be understood as a reciprocal interaction that appears complex and diverse"; all of which is understood from the creation of learning objects from the teaching-learning process of Physics and assumes beliefs, experiences, social, cultural and ideological context as a basis of knowledge .

The components of the methodology are based on the historical-cultural approach defended by Vikostky (1978), with two essential contributions: the proximal zone of development and mediation. The first is the distance between the level of resolution of a task that a person can achieve acting independently and the level that can be achieved with the help of a more competent partner or expert in that task.

This leads to student learning with a developmental approach, from which they acquire critical and innovative thinking and where the teacher, in his role as facilitator of subject-object and subject-subject interactions, maintains a communication or didactic dialogue mediated by the learning objects. Hence, the pedagogical character as a purpose in the teaching-learning process, which allows a dialectical relationship to be established between objectives, contents, methods, means and forms of organization of teaching.

Hence, the references made to what is stipulated by González Castro (1990) when he states that the media increases

motivation for teaching by presenting stimuli that facilitate student self-activity, security in the learning process and change of activity.

A fundamental aspect of the methodology when creating a new LO implies knowledge that must be codified, preserved and transferred, allowing interoperability and reuse on various platforms, which responds to the knowledge management theory (Davenport and Prusak , 2001).

The methodology is divided into three stages, which are described below:

Stage 1. Codification: is placing knowledge in a legible, understandable and organized way, so that it can be used by all the people who need it.

It is understood that the OA must contain in its structure metadata consisting of information that characterizes data, describing the content, quality, conditions, history, availability and other characteristics of the data.

In this aspect, the metadata may be in correspondence with support tools: XML, HTML, LOM, Dublin Core.

That is, the existing metadata is adopted in principle in the design of the learning object using the eXeLearning software and in the publication process it will be in correspondence with Dspace, which supports the existing repository at the University.

Stage 2. Conservation: it is the explicit preservation of knowledge.

LOs should be stored in repositories as key enablers to increase the value of learning resources; according to Maldonado *et al.* (2017, p. 17) are "computer applications that facilitate the storage, search, location and retrieval of OA, they work independently with a web interface and a search mechanism."

It is important to highlight that at this stage measures are adopted regarding the publication of the learning objects in the repository based on copyright, it is estimated that the Open Source License will be used, which allows the user to access, to reuse the object.

Stage 3. Transfer: it is the moment in which the codified and preserved knowledge (OA) is transmitted to others through technological tools.

In turn, it has a structural component divided into stages: initial, design, practice and evaluation.

Stage 1. Initial: diagnosis of the necessary conditions for the management of learning objects during the teaching of Physics in the Agronomy degree.

The objectives of the stage are:

- Raise awareness among Physics teachers of the Agronomy major regarding the management of LOs, taking into account the characteristics of LOs and their importance as support in the teaching process.
- Identify the training needs of teachers in the management of LOs.

In this stage, an initial diagnosis of the necessary conditions for the management of LOs for the teaching-learning of Physics in the Agronomy degree will be carried out.

Stage 2. Design: design of the teacher training process to manage OA, taking into account the three moments of the process: codification, conservation and transfer.

The objectives of the stage are:

- Determination of the levels of development of Physics teachers who teach in the Agronomy career.
- Design of methodological activities in the pedagogical group for teachers as managers of LOs.

Actions will be carried out to implement the stage such as training courses for teachers from a pedagogical perspective.

Stage 3. Practice: implementation of LO management in practice.

The objectives of the stage are:

- The management of LOs by teachers attending to the three moments: codification, conservation and transfer.

The stage is implemented from the development of courses such as: use of eXeLearnig, self-archive in the Repository, Moodle and Institutional Repository management course, EARCHIVE insertion of the OA.

Likewise, the three moments of OA are applied: codification, conservation and transfer.

Stage 4. Evaluation: analysis of the results of educational practice for the teaching-learning of Physics in the Agronomy degree.

The stage has the following actions:

- Perfect the methodological proposal in order to deploy it in the different courses of the University.
- Check the effectiveness of the teaching process during the teaching of Physics in the Agronomy degree based on the management of the LOs.

Evaluation actions are applied to verify its effectiveness and improvement for its implementation in the various careers of the university.

DISCUSSION

From the study carried out to develop the methodology, it was evident that teachers generally use LOs empirically as independent tools developed for specific tasks, which limits and complicates their use (the teacher must efficiently handle multiple tools to obtain a useful product.

Another element evident is that teachers use only one tool, when they can use others such as: eXeLearning, Autores, EasyProf, Cmaptool, among others.

On the other hand, there are students and the need to develop digital skills for their performance.

They agree with the authors (Menéndez Domínguez & Prieto Méndez, 2015) in establishing that the management of LOs is not a simple process, it involves factors such as: the objective and instructional design, learning style, interaction, interface, format, descriptors and processes such as: generation, search and recovery, labeling, composition.

Similarly, it is assumed with Toll Palma *et al.* (2011) when stating that in the creation of LOs their specific attributes must be taken into account, allowing the possibility of managing, using and sharing them.

The teacher, by developing the LOs and inserting them in each subject, foresees an improvement in the learning of the student capable of exploring freely, sometimes repeating topics until achieving mastery (personalized learning), appropriating knowledge with the help of an LO, to solve a specific problem. Every time it is inserted into the curricular programs, it is used and reused in other topics at a minimum economic cost, saving time and with social relevance.

As Martínez Naharro refers *et al.* (2008), the application of LOs allows the student to acquire new learning strategies, develop generic, interpersonal and systemic instrumental skills such as information

management skills, basic computing and teamwork, among others.

In general, it is concluded that learning objects constitute necessary tools to support the educational process in the Physics discipline at the university.

The application of the methodology for the management of learning objects will promote digital practices for the teacher and the appropriation of learning strategies in the students.

The methodology to be implemented will promote new strategies for the coding, conservation and socialization of learning objects through a repository.

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The authors participated in the design, analysis of the documents and writing of the work.

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