Article

Development of open learning objects for agricultural sciences under the PADDIEM methodology

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Abstract

The research aimed to develop open learning objects (OAA) for agricultural sciences under the PADDIEM methodology. The research was designed to work on the creation of Open Educational Resources (OER) in digital format as learning objects developed under instructional models that had not been worked in the Postgraduate School (CP). The OAA was held at the Postgraduate College, Montecillo campus during the first semester of 2018. In the methodology, it began with the development of a scheme with the proposal of an OAA in three parts: pedagogical, computational and graphic design. Afterwards, different instructional models were analyzed for the design of OER. Then, the planning methodology, analysis, design, development, implementation, evaluation and maintenance based on instructional models (PADDIEM) and good practices of Software Engineering was made. In this part, both its architecture and the multidisciplinary teams of each stage were highlighted. In the results, there were examples of the phases where the graphic design team participated for the elaboration of an OAA of the subject of model entity-relation of databases. To conclude, the proposed PADDIEM methodology was used to prepare OAA to be used in Agricultural Sciences.

Keywords: education, multidisciplinary teams, OER.

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Introduction

The Postgraduate College of Mexico (CP) is an institution of education, research, linkage and service founded in 1959 to solve problems in agricultural, fishing, livestock, social, forestry, etc. To achieve the above, since 1964, it has relied on different computational tools established in the Statistics and Calculation Center, which is currently part of the Socioeconomics, Statistics and Information Technology Program (PSEI).

The postgraduate programs in statistics and applied computing have been of great support for the analysis of agricultural research data and for the proposal of different research projects in the areas of artificial intelligence, databases, geographic information systems, dataware house, mining of data, educational computing, expert systems, information systems, software engineering, etc.

Since 2014, in the area of educational computing, work has been promoted with learning objects (OA) to support courses in different modalities supported by information and communication technologies (ICT) such as b-learning and e-learning Some results that stand out are the management system of learning objects for agricultural sciences (SIGEOACA) of Montes *et al*. (2017), the proposal of a management system for learning objects adaptive to learning styles (SiGOAA-EA) by García-Cué *et al*. (2017) and open learning objects based on educational software engineering (OAAISE) for database courses by García-Cué *et al*. (2018).

In the aforementioned OA projects, work has been carried out under structures and systems proposed by the authors, but no open learning objects (OAA) have been experimented under established instructional models -such as ADDIE (acronyms of five stages for the development of digital educational resources: analysis, development, design, implementation and evaluation) or the PADDIE model that adds, to the previous model, a planning stage- which are within the standards for use in various national repositories and libraries.

Also, a new methodology for the preparation of own OAA is proposed for the CP that serves agricultural sciences and that integrates instructional models, good practices of software engineering and the inclusion of multidisciplinary teams -as an education for the development of didactic skills for environments virtual, graphic designers, computer experts, among others- as a fundamental part of the OAA. To comply with the above, a methodology was proposed that included the six stages of the PADDIE model plus one of maintenance (M) resulting in PADDIEM.

To begin the investigation, the different perspectives of different authors about the term object of learning were identified. Wiley (2008); Correa (2017) agreed that OA are part of structured technological resources such as object-oriented programming (OOP). Cacheiro (2011), with a focus on education, typified them as learning ICT educational resources.

Portillo (2017) defined OA as ICT resources that should include didactic strategies for meaningful learning such as pre-instructional, co-instructional and post-instructional. Wiley (2008) defined them as any digital resource that can be reused to support learning. About the

characteristics that an OA must have, various authors such as Moreiro *et al*. (2012) highlight accessibility, granularity, interoperability, durability and scalability and that are also relevant and reusable.

On the other hand, García-Cue *et al*. (2017) explained that the OA can be designed according to their level of globality and expressed it in three layers: complete, thematic and specific course. Wiley (2008); Soto (2011); Montes *et al*. (2017) proposed another configuration of OA contemplating two parts: the computational and the pedagogical part. Meráz *et al*. (2018) added a third part: graphic design as an element that enables the creation of better quality OA.

UNESCO (2012) explained that open learning objects (OAA) are cataloged as part of open educational resources (OER) where any person can have access to them without any cost and that its use is also public. To this end, it formalized the Paris declaration of OER in 2012, where it called on governments around the world to provide open licenses, such as Creative Commons (CC) or reduced general public license (GNU GPL) to digital educational materials, including the OAA with funds financed by the state respecting the rights of the people who made them (UNESCO, 2015).

After, García-Cué *et al*. (2018); Meráz *et al*. (2018) preferred to talk about processes and not about parties, since these are a series of stages that must be carried out in order to build the OAA. In addition, three of them stood out.

Pedagogical process: to describe in a logical and sequential manner each of the actions that must be carried out in the preparation of an OAA so that it is didactic and that also influences the teaching-learning process of the student (García-Aretio, 2013). The above is achieved by two ways. The first, through OA structures proposed by different authors such as Osondon and Castillo (2006); Montes *et al*. (2017); García-Cue *et al*. (2017), where they must comply with at least introduction, objectives, theory, activities, evaluation and collaboration.

The second, supported by the stages of instructional designs for the development of educational software such as ADDIE (DDEU, 1975 in Meráz *et al*., 2018), Paddie (Navedtra, 2010), PADDIE+M or a proposal of its own. In addition, this process includes the expert in the area of knowledge in which it will be developed.

Computational process: for the programming of elements, the management of servers and networks on the Internet, the digitization of each of the elements that are part of the OAA (text, photographs, documents, videos, audios, games, etc.) as suggested Clares (2011); Meraz *et al*. (2018). Some authors, such as García-Cué *et al*. (2018) highlighted the computer structure based on instructional designs based on good software engineering practices under different models (Cascade, Spiral, XP, SCRUM, etc.) such as ADDIE or PADDIE. Also, Moreiro *et al*. (2012) highlight in this process, the management of the semantic part as metadata under international standards such as: IEEE-LOM, SCORM, CISCO, DCMI, DUBLIN CORE, OAI-PMH, among others.

Graphic design process: for the organization, production and preparation of each of the materials that will be part of the OAA in the form of templates, texts, audios, videos, games, etc. (Chan, 2006; García-Cue *et al*., 2018; Meráz *et al*., 2018). The role of the designer is to take care of the

visual part. aesthetics, corporate identity and perception theories to help in the teaching-learning process supported by cognitive ergonomics theories (González-Muñoz, 2017) and also focused on the end user, the human-machine relationship; through, from interfaces (from simple to advanced), product strategies and proposals for the marketing of the OAA (Pratt and Nunez, 2012).

In addition, Clares (2011); García-Cué *et al*. (2018); Meráz *et al*. (2018) highlighted the need to integrate groups of experts in each process or knowledge of more than one process.

After analyzing all of the above, the following question arose: how are open learning objects developed for the teaching of agricultural sciences under a PADDIEM methodology? To answer this question, an investigation was carried out that aimed to develop open learning objects (OAA) for Agricultural Sciences under the PADDIEM methodology. The assumption raised was 'graphic design and the PADDIEM methodology are used for the elaboration of open learning objects for agricultural sciences. The work is part of the field of educational research incorporating advances in the sciences and in information and communication technologies (ICT).

The results of this research will serve as a guide to develop OAA for any area of knowledge in agricultural sciences and that can also be used in national digital libraries. It is important to mention that each of the stages of the PADDIEM will be explained, but in this document greater emphasis is placed on the design stage.

Methodology

- The methodology of the open learning objects is based on graphic design and was carried out in the following way:

- An outline with the proposal of an OAA in three parts was elaborated: pedagogical, computational and graphic design. The scheme was made in the form of sets with their corresponding intersections. In each one of them, the knowledge that must be had by the people who are integrated as multidisciplinary teams was highlighted.

- The ADDIE model was analyzed. In this part, this model was explained from its appearance. Also, a brief description of its stages was made because they are the basis of the methodological proposal for the CP.

- The PADDIEM methodology was proposed. In this part, its foundation and the proposal of its architecture were shown. Also, each of the phases of PADDIEM was explained, where the activities in each stage and the multidisciplinary team that intervenes were included.

- The process and some skills of the graphic designer for the elaboration of digital materials of the OAA within PADDIEM were highlighted.

- Some examples of materials produced for the OAA were shown based on graphic design processes.

Results

Outline of open learning objects

Figure 1 shows a proposal of the three processes involved in the development of OAA: pedagogical, computational and graphic design.

Figure 1. OAA structure proposal.

Each circumference represents a process, its corresponding team of experts and the type of knowledge that is recommended that they should have. There are also three interceptions between two processes with people who know more than one area of experience, who was assigned a name or activities that they develop. The interception of the three processes results in a learning object. The inclusion of the Creative Commons legend (CC BY-ND-2.5 MX) is to indicate that it is an open educational resource that adapts to the guidelines established in Mexico and that is used by different OA developers that are already available on the Internet.

It is important to mention that the functions of the teams are not rigid as there may be people who have experience in different areas of knowledge for the preparation of the OAA. Also, there may be others that provide different elements that are not contemplated in the diagram and that serve for the preparation of the OAA. Pratt and Nunez (2012); Leal-Fonseca (2008) agree on the need to work on a project with multidisciplinary teams for the development of quality educational materials highlighting the graphic designer as an important element.

The above, coincides with the proposal made in this diagram for the design of OAA, only that Figure 1 proposes the knowledge that specialists in each area should have. Various authors, such as Clares (2011); Montes *et al*. (2017), explain that teachers are responsible for doing everything for the OA, often supported by software or OA platforms for its creation, without taking into account the three areas of expertise that stand out.

Model ADDIE

DDEU, García Cué *et al*. 2018) explained that in 1975 the ADDIE model appeared, as an improvement of the Instructional System Design (ISD) model, proposed as information systems of educational materials through computational means, developed by the US Army to give mass training to the military personnel who were sent to war. Branson *et al*. (2018) explained that the Educational Technology Center of the Florida State University (FSU) made the modifications based on proposed Software Engineering models and explained that ADDIE is an acronym of different phases in the design of pedagogical resources for digital media.

Figure 2 shows a flow diagram of the modified ADDIE model from the originals of MENC (2014) and CODAES (2015). In this figure, diamonds appear with the word AUTHORIZA, which are stages of evaluation.

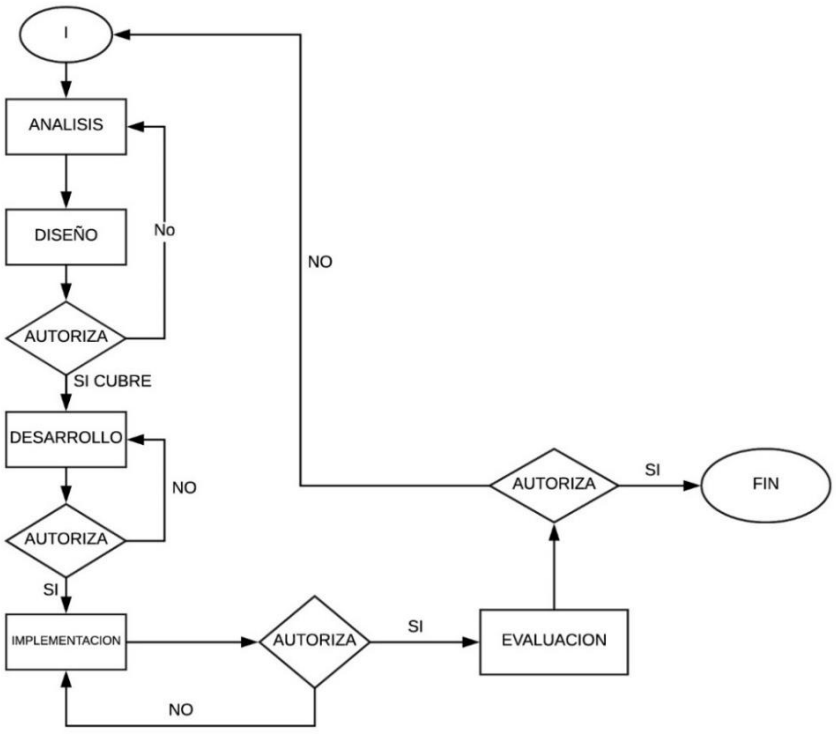

Figure 2. ADDIE model.

García Cue *et al*. (2018); Meráz *et al*. (2018) each explained the ADDIE stages for the OA:

Analysis. The objectives are defined, as well as the necessary data for the design of a learning object are collected. Also, characteristics of the audience that will make use of the OA are defined.

Design. The objectives are written, the structure and sequencing of the learning object is planned. Also, an OA project management plan is created. In addition, the analysis and design stages are evaluated.

Developing. Each one of the elements that will be part of the OA is proposed as texts (with theories, examples, exercises, etc.), elements of reflection, scripts, games, graphics, audio, video and images. At the end of this stage, an evaluation of all the materials is carried out before implementing them.

Implementation. Everything that takes the educational resource or course is integrated. Metadata based on international standards (SCORM or IEEE-LOM) are proposed. In addition, pilot tests and evaluation of the functioning, content and development of the OA are made to be able to publish it.

Evaluation. The effectiveness of the educational resource is evaluated to know if the objectives of your project have been met. The evaluation is done with questionnaires or with different rubrics for each of the ADDIE stages.

Currently, the ADDIE model continues to be used for the development of open educational resources such as the OAA (García Cué *et al*., 2018) and there are several manuals on the Internet that explain in detail each of its phases such as the MENC (2014) and NAVEDTRA (2010).

PADDIEM approach, architecture and phases

The PADDIEM approach is the result of the integration of the proposals on the ADDIE model of DDEU (1975, in García Cue *et al*., 2018), the planning phase (P) of the PADDIE (NAVEDTRA, 2010) and of good engineering practices of Software on the Maintenance stage (M). Figure 3 shows the architecture proposal. Note, that there is a rhombus with the letter E that indicates that an evaluation is made after each stage.

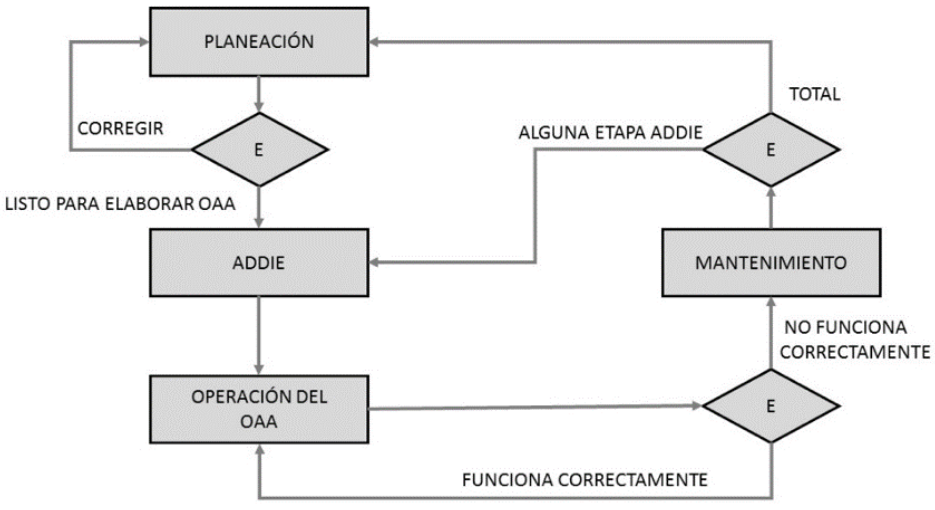

Figure 3. Architecture proposal of the PADDIEM.

From the previous figure, the following is explained:

The planning phase (P) identifies the resource needs, the problem to be solved (initial diagnosis, economic and human resources viability, scope of the project, supply, demand, end user) and the sequence of events in the development process in the manner of a schedule.

An evaluation of the planning (P) is carried out. If the evaluation is positive, each of the stages of the ADDIE Model is carried out. When finished, the open learning object (OAA) is put into operation.

The operation of OAA is evaluated. If faults are detected or you want to correct the contents enter the maintenance part (M) where the decision is made to modify everything, or it is detected in which ADDIE stage it is necessary to correct it.

In Figure 4, each of the PADDIEM stages is explained with its activities and the multidisciplinary teams that are proposed for the OAA elaboration based on Figure 1.

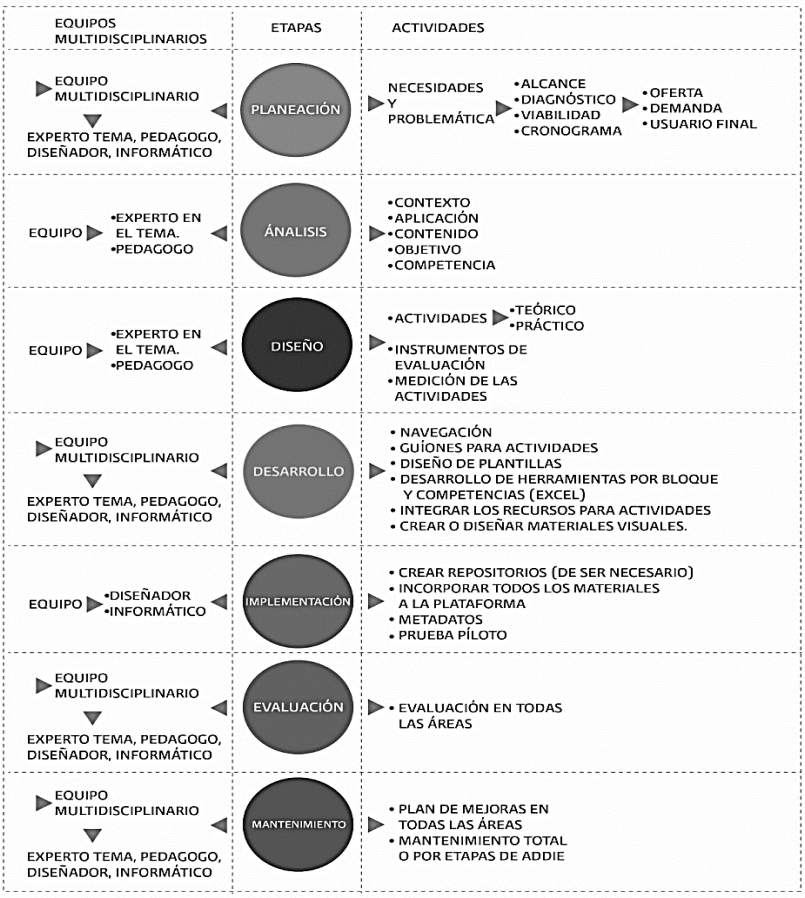

Figure 4. PADDIEM proposal.

The proposed PADDIEM is similar to that of NAVEDTRA (2010), in both the activities of each phase are explained. They differ in that NAVEDTRA (2010) does not consider multidisciplinary teams, especially graphic design.

Ordoñez *et al*. (2015) identified his model as educator for special group (ESG), which consisted of an ADDIE+M, where he proposed a suggested maintenance in working groups and not as proposed in Software Engineering as in the PADDIEM.

Some authors mention the planning and maintenance stages as something external to ADDIE and emphasize that they are not essential since they can be used or not. At present, the ADDIE model continues to be used for the preparation of OAA (García-Cué *et al*., 2018), but several authors have proposed some improvements or adaptations according to their own software development needs, many of them not mandatory in the process.

Process and skills of the graphic designer for the preparation of OAA in PADDIEM

To exemplify the PADDIEM model, only the stages where the working group of the graphic designers are involved, their skills, as well as some of their activities for the development of an object of learning the subject of the model entity-relationship of agricultural databases will be highlighted:

Planning. Actively participates in each of the decisions of the project, especially those related to the aesthetics, content, navigation routes and users to which the OAA will be directed.

Developing. It proposes, together with the rest of the work teams, a navigation map of the materials selected for the OAA, for example, for the subject of entity model-database relationship (Figure 5). Then, he participates in the development of each of the materials, whether digital, interactive or printed. In addition, both design and computational teams work on the interfaces for an adequate human-machine communication.

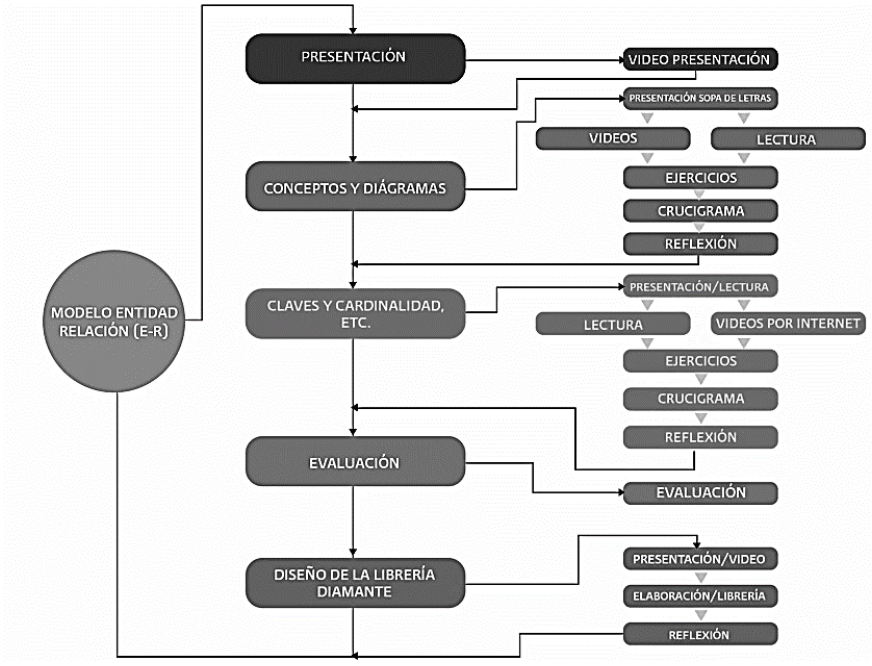

Figure 5. Materials proposed for the OAA and navigation map.

Implementation. Work together with the computer expert to adapt the materials to the OAA repositories.

Evaluation. Participates in the development of instruments to verify if the OAA is suitable for the project.

Maintenance. Verify the proper functioning of the OAA. Also, correct typographical, style, visual, auditory errors, etc. Update the new materials and collaborate with the entire multidisciplinary team so that the OAA is working properly.

An example of the work of the graphic designer in the development stage is shown in Figure 6, which contains the different steps that must be followed for the development of digital educational materials. It starts with the choice of theme, information gathering, organization of information (all through folders and file formats, examples, photos, videos, audios, text files, etc.).

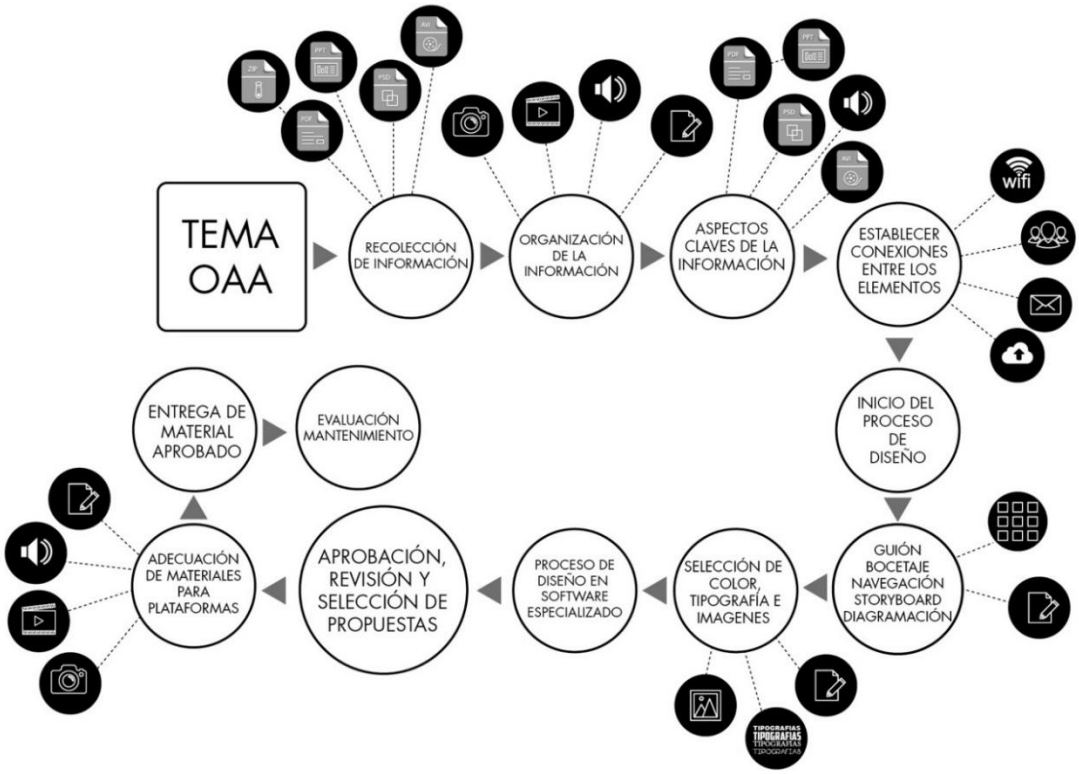

Figure 6. Proposal of the graphic design process for the preparation of digital materials.

Later, the key aspects of the information are identified, the establishment of the connections between the elements, the beginning of the design process, scripts, sketches or storyboard and layout. To finish, the selection of color, typography and images is made, development of the elements in specialized software, review and selection of proposals based on cognitive ergonomics and user-centered design. Also, delivery of approved material. Finally, prepare the materials for the OAA repositories or educational platforms.

It is considered important to mention that Figure 6 is a general scheme. The construction of some digital educational materials may have minimal variations in certain processes.

In addition, although there are no absolute rules for the design of an educational interface, this does not mean that the principles of homogeneity of elements, composition and basic language of the design of educational virtual environments that favor cognitive ergonomics should be ignored.

Another contribution of the team of graphic designers is the development of simple guides so that different project participants can begin to make each of the OAA materials and comply in a timely manner, as shown in Figure 7.

Figure 7. Guidelines for the preparation of digital materials.

An example of the process for making a video for OAA is shown in Figure 8.

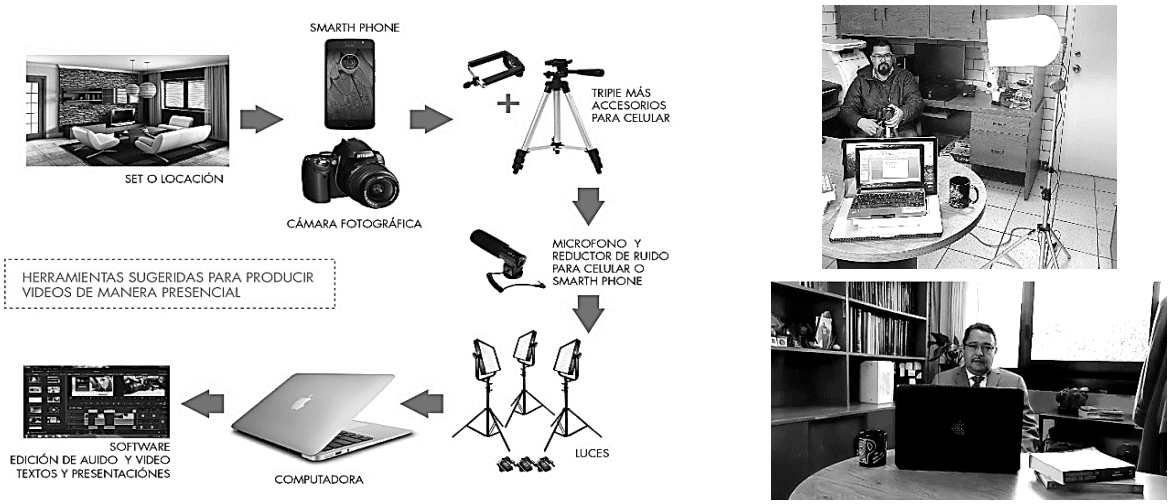

Figure 8. Making videos.

The process begins with the choice of set or location taking into account recording schedules with less noise, cleanliness of the site, adequacy of place to make it as aesthetic as possible for the camera. After, the selection of equipment camera or smartphone, tripod, microphone and lighting fixtures. Later on, the entire team is integrated, making the corresponding focus and audio tests. The video is recorded considering that the incorporated elements are inside the camera frame.

Finally, the material is recorded on the hard disk of the computer and it is edited with software for editing open source license videos, free or with a paid license such as imovie, movie maker, after effect, etc. For the publication, the characteristics of the server to be uploaded must be verified, many times the videos use many bytes and must be compressed to be viewed. You can use handBrake which is free software that works for different operating systems.

Another methodology is shown in Figure 9 to make videos using software such as powtoon, after effect, premier, etc.

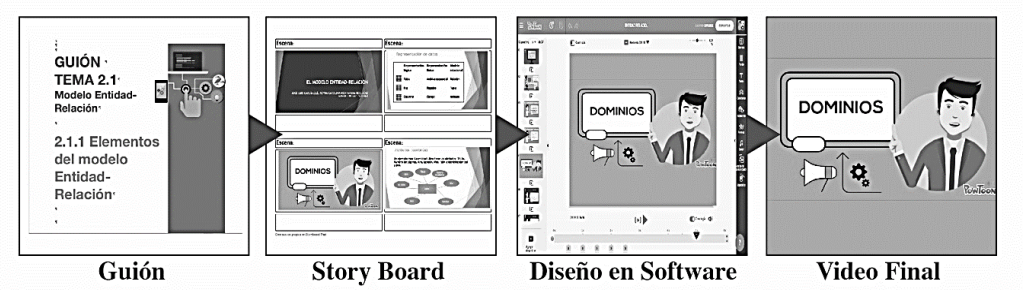

Figure 9. Methodology for making videos with software.

It begins by making a script of the subject that is going to be treated in the video. Then, the materials are selected to create a story board where everything is ordered and characters, animations, colors, fonts, etc. are chosen. Later, we proceed to the development of the video using software (previously tested) as powtoon taking into account what is proposed in the story board. Next, the video is tested to see the transition times between elements and modify errors. Finally, the finished video is saved in mp4 or other formats. If the video is uploaded to a repository, its size must be taken into account, since it is often very large (or heavy in bytes) and must be reduced. To do so, you can use software that allows you to compress such as the HandBrake.

Materials produced for the OAA based on graphic design processes

Figure 10 shows examples of materials produced based on graphic design processes.

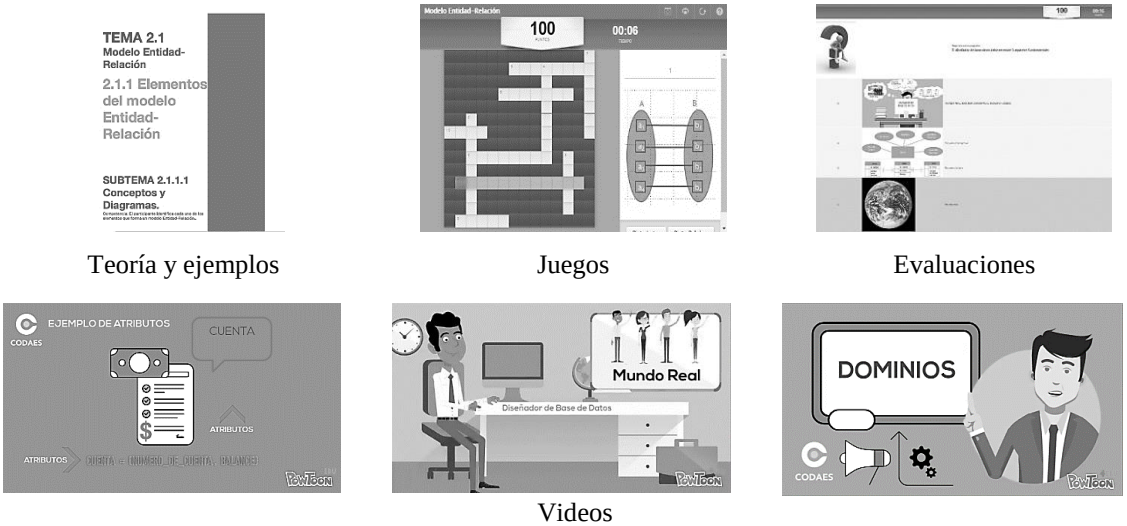

Figure 10. Materials produced.

Finally, in the PADDIEM methodology there are constant evaluations (Figures 2 and 3), many of them carried out with rubrics previously elaborated by the multidisciplinary team. Within PADDIEM, it is not possible to continue to the next stage if the established parameters are not met, this guarantees that the OAA complies with the objective for which it was created. Later, an investigation is contemplated to students who occupy the OAA and contrast them with others who take the same topic in person to see if the results are similar or different in the teaching-learning process.

Conclusions

The objectives of this investigation were met, and the assumption is not rejected. The proposed PADDIEM methodology was used for the elaboration of open learning objects to be used in agricultural sciences. A methodology was presented that includes multidisciplinary teams -specialists in the area of knowledge, pedagogy, graphic design and computing- where each expert performs his activity, which allows to meet the life cycles of each of the PADDIEM stages.

Graphic design, in addition to providing visual and aesthetic quality, supports cognitive ergonomics with the purpose of knowledge of the OAA remain in the long-term memory. Likewise, the graphic designer fulfills diverse functions that will directly affect the development of the design of the OAA. Their work contributes to the adequate perception of the contents of the OAA and their permanence in the mind of those who use them. The OAAs based on the PADDIEM methodology can work in different repositories, for example, digital communities for learning in higher education (CODAES) or Wordpress.

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