DIGITAL TOOL FOR BLENDED LEARNING FOR TEACHING VISUAL EFFECTS

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ABSTRACT

The use of digital and blended digital learning modes is becoming more popular in teaching practice at various levels of instruction. This article reports a case study with a strong experimental approach in which a digital learning object (DLO) was developed to assist in the pedagogical practice in higher education (in the audiovisual area).
The objective of the research was mainly to evaluate the pedagogical contribution of DLO, however, this article is restricted to demonstrate what were the methodological paths taken during the research process for the development and conception of the tool (DLO), using theoretical references from the design area, pedagogy (regarding the construction and validation of digital learning objects), and the methodologies defined for their subsequent evaluation and validation.
This article intends to contribute mainly by pointing out the design strategies adopted for the conception and creation of a Digital Learning Object for Blended Learning. Future works will present the subsequent validation results, pointing out the paths taken and new research paths to be followed to complement and further contribute to research regarding the importance of DLOs in the teaching practice of higher education. Besides, it is believed that the more research and experimentation with the construction of new DLOs and the sharing of the methods used, the better for the development, reflection and definition of better design strategies to more effectively reach the objectives initially proposed for the digital learning tool.

KEYWORDS

Digital Learning Objects, Match Moving, Undergraduate Degree, Visual Effects, Audiovisual Production, Mobile and Virtual Learning

1. INTRODUCTION

The teaching experience in undergraduate courses in the audiovisual area, more specifically in the production of visual effects (VFX) in which occurs integration between real and virtual images (match moving), enabled the said researcher to notice to certain difficulties during the teaching and learning process.

The production of VFX with match moving involves diverse techniques and technologies, besides the most varied concepts and theories of the cinematographic area. Bibliographical references on this stage of production and technologies involved are found in the following works consulted (Prata & Nascimento 2007, Hornung 2010, Jackman 2007, Dobbert 2005, VES 2010). This great variety of knowledge that needs to be combined, integrated in a transdisciplinary way at the time of practical teaching activities, presented a high degree of difficulty in its execution. The step named "data collection" was the most critical when compared to the other stages of production.

During this stage, the students need to note several values referring to the configurations of the most diverse devices and filming environment. Due to this enormous amount of data to be collected (varying in quantity depending on the degree of complexity of the scene shooting), forgetting the collection of certain values may be crucial for not achieving success, failing to execute audiovisual production as an all, or in the best scenario, being necessary to spend more time to be able to execute it, bursting the anticipated budgets.

Starting from this presented difficulty, the present researcher proposed to design a prototype of a digital learning object (DLO) to assist in these practical teaching activities.

2. TOOL DEFINITION / PREVIOUS SEARCH

Starting from the idea of developing a digital learning object (DLO) to aid in the practical learning activities mentioned above, initial research was carried out in search of some existing tool with the functionality close to that desired by the prototype to be created.

For this, the prototype had to be minimally defined in relation to its objectives: a) to assist in the indispensable collection of data for later reconstruction of the real characteristics in the three-dimensional virtual environment (computer graphics software); b) prevent essential and important information from being forgotten; c) create a methodology for collecting the data in order to organize it; d) if possible, automate part of the task of reconstructing the virtual environment from the actual data collected, using programming so that from the data collected, it is possible to generate script for the automation of the creation and configuration of the virtual elements.

After this guiding definition, research was done on computer software (Windows, Linux and Mac operating systems), App's for mobile devices (in App's distribution stores such as Google Play, App Store, Amazon Appstore, Uptodown, Aptoide, APKPure, F -Droid, Uptodown), and online tools (websites) that could offer the same solutions.

No software, App or website was found with the characteristics listed. The closest application that, however, does not specifically meet the listed goals was the "Shot Designer" App available for Mac / PC / iOS / Android. This application allows collecting several data during the filming, besides having several and relevant other functions, however, it is not directly oriented to the production of VFX and Match Moving. In addition, it does not offer the function of automating part of the work of rebuilding the real environment for the computing graphics imaging (CGI) software.

3. RESEARCH PROPOSAL

Considering that the tool to be designed and tested has as one of its objectives its use in an educational environment, the research proposal, after methodological appropriateness (better delineated forward), was defined as follows: a mini-course with a total duration of 4 weeks, with activities 5 days a week, with 3 hours of duration per day, totaling a total workload of 60 hours.

From these four weeks the first two weeks reserved for teaching the theoretical part, technique and realization of the filming to capture the raw images, and the final two weeks devoted to the production of the images in CGI software and composition of the virtual images with the real ones.

In this context, each of the final weeks was dedicated to the production of one of the two practical exercises proposed during the mini-course, in addition students were randomly divided into groups and performed the exercises in different order and with and without the aid of the tool in one or the other exercise, something explained in greater depth in the next sections.

At the end of the mini-course, in addition to providing the practical exercises performed during the mini-course for subsequent blind evaluation of the material by third parties, they respond to three research forms responsible for evaluating the tool (DLO) in three dimensions, which are:

1. Analysis of the concept of the product.
2. Evaluation of the characteristics of the product regarding its relevance.
3. Assessment of the characteristics of the product regarding its adequacy.

The research involving the Portuguese research institution and being carried out in Brazilian territory is classified as international research by Brazilian institutions.

The entities involved are Faculty of Science and Technology (FCT) of the New University of Lisbon (NOVA), Portugal, and the Federal University of Paraíba (UFPB) in the city of João Pessoa, Brazil.

In addition, because it involved human beings (students of undergraduate courses related to audiovisual production), it needed to be submitted to the Research Ethics Committee (CEP) and later to the National Research Ethics Council (CONEP) in Brazil.

The investigation received the CAAE case number: 03763418.6.0000.5188, it was appreciated, and its methodology and ethical aspects approved for its execution, according to the presented planning.

4. RESEARCH METHODOLOGY

Considering that no tool/application with such characteristics was found, and could, therefore, be classified as innovative, we set out to the methodological definition to later design it, evaluate it and validate it.

After a bibliographic review to look for the best methodological strategy to be adopted, the research was classified based on its objectives as exploratory and based on the technical procedures used as bibliographical, research that field and experimental study.

Based on their objectives was framed as an experimental method (Gil 2002, Singh 2006).

Regarding the technical procedures, it was classified as "bibliographic" (Gil 2002) because it will use all the research repertoire already developed and available in articles and books related to digital design methodologies and digital learning objects, to support the whole tool design, evaluation, and validation process. It was also classified as "field study" (Gil 2002) because it will have the application of forms and different methods of analysis for the evaluation and validation of the tool (such as Decis, NPS and MaxDiff scales). In addition, also classified as "experimental" (Gil 2002) because it will seek through the ministration of a mini-course and control of the research environment, conduct a blind analysis of the practical work developed by the students participating in the research/mini-course.

The intention in the experimental stage was to try to infer qualitative improvement in the practical exercises realized with the aid of the tool when compared to the exercises without the aid of her. In this way, we seek to understand if the contribution of the DLO tool is more restricted and visible in the teaching activity, or if it also adds performance contributions in the execution of the works that it assists (due to the possible time gain due to the automation capabilities in the work of transposition of collected data to CGI software).

4.1 Variables Control

For the experimental part of the research, methodological precautions were necessary for its correct execution, such as the manipulation of an independent variable, ways of controlling and observing the effects, random distribution, among others. The forms of control that needed to be observed and adopted were as follows:

1. Random distribution of the research participants into 4 groups.
2. Computer lab, where the practical activities of the mini course were executed, with all the computers (workstations) with the same technical specifications, that is, the same hardware and software configurations, so that possible differences could not interfere in the quality of the practical exercises developed.
3. Subdivision of time into equal sections for the execution of each of the practical activities during the mini course.
4. Same practical exercises with the same levels of difficulty (equivalents) to be performed by all students participating in the mini course because creative freedom would make it impossible to compare qualitatively between the practical works developed.
5. Definition of the independent variable and the control group, where the variable was the use or not of the tool (DLO) in the aid of the data collected during the filming and later transposition of the data to computer graphics software using the script generated by the tool.
6. The use of the same video images shot together by all participants of all groups at the same time (but each group collects data during the shooting in a different way) so that they can perform the integration exercises with the same degree of difficulty.
7. The avoid completely the practical exercise with similar activities before the experiment so as not to incur into the "training effect" and compromise the samples later.

Works that served as the basis for this organization and methodological care for the experimental part for consequent statistical and ethical validity were (Goodwin 2010, Coolican 2009, Hair et al. 2010, Singh 2006).

4.2 Model for Experimental Execution

Due to the number of computers available in the computer lab and in view of the limitation in the number of participants that the available infrastructure would allow, the experimental part of the research was designed to be performed inter-subject and intra-subject, for what even counting a reduced number of participants, it was possible to obtain representative statistical data in the final results.

For this the participants were randomly subdivided by lot into 4 groups with 5 members each, a total of 20 participants to start the mini course. The groups were named from one to four (G1, G2, G3, and G4). In the following table it is possible to understand the order of execution of the practical exercises (which group started the practical activities by exercise A or B) and in which of exercises each group used and did not use the tool to aid the execution of the activity (where w = with the tool wo = without the tool).

Table 1. Subdivision by groups and order of execution of activities

Order AB	Order BA
G1 – A(w) B(wo)	G2 – B(w) A(wo)
G3 – A(wo) B(w)	G4 – B(wo) A(w)

5. PROTOTYPE DEVELOPMENT - CONCEPTUAL RESEARCH

The prototype was developed from two parallel theoretical frameworks based on preliminary bibliographic research: the one related to fundamental components of design, encompassing concepts such as user experience evaluation methods, sketching user experiences, instructional design, user experiences, user interface, theoretical referential works as (Vermeeren et al. 2010, Buxton 2007, Wiley 2000, Piskurich 2015, Greenberg et al. 2012, Adão & Jacob 2011); and the one related to the specific pedagogical components for the design of digital learning objects (DLO) through works like. (Dias et al. 2009, Prata & Nascimento 2007, Ghisi 2016, Neto et al. 2017, Nocar 2016, Fuchs, Bruch & Annegarn-Gläß 2016, Penteado, Gluz & Galafassi 2013, Braga 2014, Braga 2015, Tarouco 2003, Tarouco 2014, Smith 2004, Zucherman 2006).

In this way, it was tried to consider both the primordial characteristics for the development of a new tool as digital media, focusing on the identification of the opportunity for innovation and the creation of a new product/functionality; as well as considering the essential characteristics so that this new digital tool can also be useful, recognized and conceptually framed as a DLO.

Considering that the purpose of the research was not restricted only to the creation of the tool itself, but also its validation in its technical and pedagogical criteria, the basic elements for its development were from the beginning related to the posterior form of evaluation and validating of the prototype.

After the in-depth study of several works related to the design, production, and evaluation of DLO, it was realized that there is no definitive methodology on how to conceive and mainly evaluate a Learning Object (LO). A study that exemplifies with propriety is done by Neto et al (2017) where, through a systematic review of the specialized literature, they presented the main methodologies and instruments for evaluating LO found in the SCOPUS database, published between 2005 and 2015.

In this comparative study, 34 different methods of analysis of learning objects were included and among these are:

> (...) from evaluations composed of only two criteria (Morgado, Ruiz and Peñalvo, 2007), until evaluations that consider fourteen dimensions (Marzal and Pedrazzi, 2015). Nevertheless, it can be said that in general, the main criteria considered were pedagogical and usability (Neto et al 2017).

Based on this study and its others works with content related to LO evaluation mentioned above, a survey and evaluation of what characteristics each of these methods used in their evaluations were made. The objective was to identify and select the most common characteristics among these already existing and reported assessment methods.

Some of the existing evaluation methods whose characteristics have been studied: Reeves, LORI (Learning Object Review Instrument), MERLOT (Multimedia Educational Resource for Learning and Online Teaching), HEODAR (Herramienta para la Evaluación de Objetos Didácticos de Aprendizaje, Quality Criteria, Elements Determining Quality, BECTA (British Educational Communications Agency), DESIRE (Development of a European Service for Information on Research and Education), LOEM (Learning Object Evaluation Metric), Q4R (Quality for Reuse), CNICE-MED, Open ECBCheck (E-learning for Capacity Building), QEES, LOQEVAL (Learning Objects Quality Evaluation), TAM (Technology Acceptance Model), LOAM (Learning Object Attribute Metric Tool), LOAM (Learning Object Acceptance Model), Model CIPP (Context, Input, Process, and Product), among others.

We defined 39 characteristics to be used in the design and consequently in the evaluation of the prototype. Of these, 17 more directly related to fundamental concepts of design and 22 characteristics with concepts of DLO.

The following table shows the list of the 39 final attributes with a classification to indicate the theoretical reference base (Ref. T.) related to each formatted characteristic. These characteristics had to be constituted in attribute format since these characteristics were designed to be used both in the form of relevance and in the form of adequacy to be applied to the participants.

The difference between the forms is that in the relevance form uses all 39 attributes, while the appropriateness form uses only 16 of these attributes, 8 of which are design fundamentals and 8 are related to the DLO design. The reduction for the 16 adequacy attributes was based on the attributes most frequently mentioned in the different methods studied.

Table 2. Main theoretical references selected to guide prototype development and future evaluation and validation

Attributes	Main Ref.
Accessibility - internet dependence; accessible by any browser and operating system.*	DB-UI
Reuse - reusable in different contexts of teaching and audiovisual production, serving as a reference for other teachers.	DB-UI, LO-GA
Pedagogical relevance - appropriate and relevant in the educational context in which it is inserted.	LO-GA
Adaptability - navigation options to fit the needs of the student, making it use intuitively.	DB-UI
Aesthetics - layout, and choice of elements such as texts, links, images, videos. Considering the limitations on forms.*	DB-UI
Comfort - a perception of a comfortable feeling while using the tool.*	DB-UI, DB-Erg
Utility - a perception that the use of the tool is valid.*	DB-UI, DB-Erg, DB-UX
Organization - a perception of organization (way of navigation and subdivision in stages).*	DB-UI, DB-Erg
Supporting documentation - information about the tool. Contained in it and in the site related to the doctoral research and the tool.*	DB-UI, DB-Erg
Technical functionality - if it fulfills its purposes: assistance in data collection and automation in the transfer of these to CGI software.*	DB-UI, DB-UX, DB-Usb
Ease of use - a perception of ease of use of the tool.*	DB-UI, DB-UX, DB-Usb
Self-explanatory - self-explanatory capacity perception during its use.	DB-UI, DB-UX, DB-Usb
Error messages - when they occur clearly identify the error that is occurring and presents a solution to it.	DB-UI, DB-UX, DB-Usb
Efficiency - a perception of being competent, productive, of achieving the best yield with the minimum of errors and/or expenditures.	DB-UI, DB-UX, DB-Usb
Convenience - a perception that it can be used to uncomplicate a routine; which can bring advantages to the person using it.	DB-UX
Economic value (cost) - free.	DB-UX
Satisfaction - contentment, pleasure arising from the accomplishment of what is expected, of what is desired in the use of the tool.	DB-UX
Interactivity - allows the individual to interact by making it possible to choose which data and information the user want to collect or have access to.	DB-UI
Collaborative learning - enables the partnership between students/users to better perform activities.	LO-GA
Pedagogical objectives - identifiable and appropriate to the target audience. Assistance in the practical activities of audiovisual production with real x virtual interaction.*	LO-LA
Language - favors understanding and learning.	LO-LA
Challenging - it brings forth, instigates, provokes a confrontation, puts itself to the test.	LO-LA
Feedback - received by the teacher during the execution of the activities was important for the use of the tool and understanding of the related content.	LO-LA
Autonomy - allows students to carry out activities without teacher intervention, encouraging exploration and involvement.*	LO-LA
Content - addressed in a clear and precise manner, with adequacy and consistency to the target audience. It hasn't omissions or prejudice.	LO-LA, LO-P
Pedagogical appropriateness - presents conformity to the educational context in which it is inserted.*	LO-GA

Active Learning - Leads the student from the passive listener role to an active learner who builds their knowledge (learning to learn).	LO-P
Motivation - a set of processes that give the behavior an intensity, a direction determined during the use of the tool.*	LO-M
Quantity of information - enough and not excessive.	LO-GA
Coherence - logic, meaning between the contents, the objectives, the activities developed, the evaluation and the profile of the student.	LO-SLO
Playfulness - a perception that the use of the tool is pleasant, fun.	LO-P
Instructional structure of orientation to the student - quality and sufficiency of the instructional contents in the website of the tool.	LO-P
Help in learning - provided by the tool as an educational resource (learning object).*	LO-P
Instructional structure of orientation to the teacher - quality and sufficiency of the instructional contents in the website of the tool.	LO-P
Metadata - present on the tool's website in accordance with the standardization of Learning Objects repositories.*	LO-P
Medium level of requirement - the demands necessary for the student to access, interpret and process the instructions of the tool and make use of it.	LO-GA
Content quality - concepts, information, references, images, etc. used in the tool (reinforce key points and significant ideas).*	LO-TA, LO-P
Multimodal text - when integrating text and image or text and video into the necessary moments for a better understanding of the concept to the user.	LO-P
Language - English language, international use, majority use in the CGI and audiovisual software area.*	LO-LA

Table 3. Legend - Main Theoretical References of Attributes of Table 2

DB-UI	Design Basics - User Interface
DB-UX	Design Basics - User Experience
DB-Erg	Design Basics - Ergonomics
DB-Usb	Design Basics - Usability
LO-GA	Learning Object - General Aspects
LO-LA	Learning Object - Learning Assessment
LO-P	Learning Object - Psychopedagogy
LO-M	Learning Object - Motivation
LO-SLO	Learning Object - Adequacy of Learning Objectives
LO-TA	Learning Object - Teaching Assessment
*	Attributes selected for Adequacy Form

The explanation of the attributes used, therefore, serves to define methodologically the design, technical and pedagogical qualities, fundamental for the prototype design process and later to proceed with its evaluation and validation.

5.1 Definition of Tool Features

The main characteristics for the design of the prototype were as follows:

1. Previous tips on measuring instruments.
2. Data collection from cameras (legacy and physical).
3. Data collection of natural light.
4. Data collection of artificial lights (standard and photometric).
5. Data collection of reference objects (reference balls, plans, reference rod).
6. Alert for other important references (color checkers, references for camera trackers, creation of photos or film in 360 degrees for reflections).
7. Data collection for render setup.
8. Capability to utilize the data collected to automate the process of reconstruction of the real elements into virtual ones in the computer graphic image (CGI) software.

5.2 Technical Research

Technical research is conceptualized as being part of the research focused on which technologies to adopt for the practical execution of the prototype.

For this stage, it was based on some assumptions/limitations regarding the technical capacity and training of the researcher: a) the professor and researcher in charge does not have any knowledge of current programming language, already had contact with programming languages such as Turbo Pascal, Clipper and basic programming of batch files, however are obsolete and outdated languages; b) the research does not have a team or any professional in the field of computer science to assist in programming tasks; c) for the implementation of the automation feature it is well known that at least the programming language used by CGI software it is necessary.

5.2.1 Prototyping Platforms

Due to these conditions, preliminary research was done searching for Prototyping Platforms (sketch and mockup), because currently there are several platforms that besides designing App's for mobile phones, it is also possible to program them and design functional products without needing to know programming languages. In addition, it is possible to also test them on various mobile devices and submit them after finalized to distribution stores of Apps like Google Play and App Store.

InVision, Prott, Mockup.io, JustInMind, Mobincube, Appy Pie, OutSystems, AppSheet, GoodBarber, AppMakr, Axure, Instappy, Sketch, among others, were tested (with respect to technical resources, ease of use, difficulties, limitations, price of use).

The great potential of these platforms that present integrated solutions is that they propitiate what comment Tarouco et al.:

> Authoring tools are essential resources for teachers to develop digital pedagogical content without the need to know a specific programming language. (Tarouco 2014).
>
> The evolution of authoring tools has contributed to a new scenario in which the production of digital educational material has been less and less restricted to the group of programming and design experts. Tools that provide the addition of interactivity and multimedia resources to digital content, without the need for programming, have provided the teacher with a new panorama, in which he sees himself not only as a user but also as a professional able to prepare their own Learning Objects. (Tarouco 2014).

In addition to these platforms with complete solutions, other large corporations' platforms were also researched for the creation and prototyping such as: Google App Maker (with G Suite for Education – Google Apps), Visual Studio LightSwitch (Microsoft), PowerApps (Microsoft Office 365).

The research was based on finding a way to enable the prototype with the imagined characteristics but through a process not very complex, considering the concept of an DLO as defined by Wiley (2000), Tarouco, Fabre & Tamusiunas (2003) and IEEE (Institute of Electrical and Electronic Engineers) in Braga (2014) there is a concern that it can be used by other teachers (use and reuse/reusability), as well as the possibility to serve as a reference so that other educators can also design their own DLO suited to their needs. In this context, choosing open source technology and good accessibility meets these properties.

After these technical and technological investigations, it was concluded that such platforms could even enable an App that would allow the aid in data collection, meeting almost all the features listed initially. However, the latest and most innovative feature of automating part of the production process would not be possible without having to learn some programming language to interact internally with one of these platforms (noting that not all of them offer this possibility of more specific programming that goes beyond the basic functionalities offered).

In this way, it was decided not to use any of the existing platforms, but rather to use another set of digital tools to achieve the goal completely without needing to learn a new programming language, besides that what it would already be necessary (the CGI software language).

The solution found was to use the technologies available through the Google Forms and Spreadsheets and in an integrated way, to complement and make feasible the programming of the functionalities, the use of two add-ons developed by CloudLab - Part of New Visions for Public Schools, which are the "autoCrat" and "copyDown".

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Through several technical tests, it was possible to conclude that with the union and integration of these tools it would be possible to meet all the characteristics of the tool. In addition, the programming part for the generation of the automation function could be developed through basic instructions of calculation and automation through form formulas, not needing to learn new programming language. Thus, it would be a more affordable challenge than learning a programming language like Java, Visual Basic, C, C ++, C #, F #, as well as a database programming language like SQL.

5.2.2 CGI Software and Programing Language

There is currently several professional CGI software for production of animation and three-dimensional graphics computing. Some examples used in the entertainment industry for animations and visual effects are Maya, Houdini, Cinema 4D, Softimage, Lightwave, Pixar RenderMan, 3D Studio Max, Blender.

Many of this software have their own programming language known as Scripts, which allow you to do automation through command lines, even creating plug-ins and add-ons. Some examples of these languages are the Maya Embedded Language (MEL) used in Maya software, HSchipt used in Houdini software, COFFEE used in Cinema 4D software, LScript used in Lightwave software, MAXScript used in 3DS Max and Python language used in Softimage, Blender and also accepted in Houdini and Maya software.

In this context, in order to be able to execute the said automation characteristic by the prototype, it was necessary to choose one of this software and its respective programming language. In this process of choice, although the Python language is interesting because it is accepted by several CGI software, the previous experience and greater professional baggage of the teacher and researcher in the use of the software 3DS Max, has made that it was preferred, together with the MAXScript language. This choice led to the need to deepen the learning about the language, its commands and the understanding of its possibilities and limitations.

After these studies, several tests were carried out to find out the viability of the implementation of the proposal and it was discovered that practically all the necessary characteristics could be programmed through the language MAXScript, except those used to rebuild the natural lighting system. Clarifying better, the creation of the natural light system could be performed by Script, but it is not possible to transpose the variables (data) referring to the system.

To remedy this deficiency, a satisfactory solution was found at the end of the execution of the Script to create the natural light system, leave the screen open with all the properties and fields for insertion of the data and display at the same time on another screen through an pop-up all data collected to be copied and transposed to the software's natural lighting system, facilitating this process.

It is important to note that in addition to creating a script for automation in the use of the chosen software, all the data collected by the tool is also made available to the user of the tool so that they can be used in any other CGI software manually.

5.2.3 Definition of the Variables to be used

After defining the technologies to be used to produce the prototype, a study was carried out of which variables could be interesting to be used in the tool.

As an example it is possible to mention: the standard lights, of 47 possible attributes for its creation and configuration, were selected 11 for use in the tool, besides the positioning and name data, reaching 15 attributes; or the Physical Camera, that of a total of 77 possible attributes (18 commons with other camera types added to other 59 specific attributes) were chosen 21 of these attributes, plus name, position, and angle of inclination, reaching 28 attributes.

Thus, as in these elements, it was necessary to select as to which attributes were the most important and relevant to be included in the tool, all other elements of the prototype passed through the same bottleneck of attributes.

For this selection was prioritized in the first moment the essential attributes for the correct configuration of the element, so that it could present the same characteristics of the real element used in the set of filming. In second filtering, certain internal configurations of the CGI software were selected that could also facilitate the representation of certain physical (real) characteristics of the elements. Were left out the attributes related to more specialized and finer (detailing) configurations whose function is more relevant within the software itself during its use and rendering tests (generation of the final image).

5.2.4 Definition of the Number of Elements that the Prototype will Support

The tool will have the following characteristics and technical capabilities in data collection: a) shot location information; b) visual effects information; c) camera data collection (limit of 3 cameras at the same time in a scene, choices between legacy or physical type); d) lighting data collection natural and/or artificial (limit of 1 natural light in a scene and 8 artificial lights, limited of 4 lights that each type - standard or photometric); e) data relating to reference objects (reference balls for incidence light angle and color of light; reference plane to the place that will receive shadows and reflections from virtual 3d object or character; reference rod for size proportions and shadows); f) reminders about other important types of reference instruments and images/film to be produced for specific situations (color checkers, chroma-key references for camera trackers and the creation of photos or film in 360º for reflections); g) data collection for render setup; h) presets for 3DS Max File.

At the end of the production of the prototype, after the effective tests, were used between fields necessary to meet the attributes of all possible entries of all possible elements, plus the necessary fields for navigability and tool programming, a total of 319 fields of data.

5.3 Prototype Construction

To assist in the implementation of the prototype items such as navigability, freedoms and technical limitations, elements of support, language, license, website and repositories of learning objects were thought, discussed and used.

5.3.1 Navigability

In order to contribute to the project execution, programming, navigability and interface, some UML Structures (Unified Modeling Language) Diagrams were created.

The most used was the Use Case Diagram, focused on the presentation of features and characteristics of a system and the Activity Diagram, which contemplates the various tasks performed in the execution of an activity.

Such supports were essential for better organization of the navigability, ordering of the screens and options of routes for the task of data collection, as well as support in the tests and definition for the final layout. Because they are large diagrams it was not possible to make them available in this article.

5.3.2 Technical Design Freedoms and Limitations

The technical choice of the digital tools for tool development presented, like any other possible option, positive and negative points.

Some of the good points were: a) the tools are all freely accessible, thus highlighting the possibility of developing DLO through affordable and zero cost technologies, encouraging other teachers to create their own tools to aid in their teaching and learning activities; b) the programming language can be considered as open source, since the researcher gives full permission to the visualization of the formulas used to program the prototype so that other teachers can adapt the solution found to other needs; c) the solution does not use any programming language advanced beyond the MAXScript of the software 3DS Max, because, for the transposition of the collected data and its automation for the creation of Script, only spreadsheet formulas were used; d) the technology chosen for designing the prototype allows it to be used in any device and operating system, in both computers and mobile devices, making it very accessible and adaptable.

Some negatives: a) design limitations because the use of Google Forms for data collection implied technical limitations in the possibilities of layout configurations, navigability, among others. However, since it has been on the market a long time, and it is used by millions of people around the world, it already has undergone continuous improvements and corrections, adding design solutions (UI, UX, ergonomics, usability), already tested, corrected and improved; b) technological dependence of companies that provide the technologies, because despite the "property" through login and Google account, the company can change some feature or discontinue some function without prior notice and compromise the resources already implemented; c) despite the practicality and adaptability of being an online tool that can be used in any web browser of computers and mobile devices of any operating system, it is needed the device to have an internet connection to work. That is, you cannot use the device offline, compromising its utility in remote locations and without a data connection.

Layout limitations caused certain design tests (layout, ergonomics, usability) to be suppressed because the creation did not have the aesthetic and functional freedom of an application created from scratch without the aid of a third-party tool.

5.3.3 Elements of Support

In order to meet several of the attributes and complement the tool's functionalities, some animations and static images were produced to aid in the understanding of some concepts within the tool. With the same intentionality, it is also used images found on the web (all credited sources).

In this context of support, references were used through hyperlinks to some specific websites, which have more detailed technical explanations and online tools to assist with specific calculations in the audiovisual area. As examples we can mention tools for conversion among units of measurement of light intensity (lux, lumens, candela, watts); online tool "color wheel" to find the RGB code of a certain color; as well as a tool for calculating the Field of View (FOV) of the camera used for filming (more specifically the angle of view in horizontal direction degrees).

In addition to the use of static images, animations and hyperlinks, the tool itself contains some explanations to avoid that the student or inexperienced user provides wrong data, trying to minimize possible errors of understanding technical terms.

5.3.4 Idiom

Field research was designed for execution at a Brazilian university, mainly due to the following factors: a) technical availability for the execution of the activities (infrastructure with filming equipment, audio capture, computers for editing and composition of the material, audio studio and video, classrooms), with the necessary control of the variables (laboratory with equipment with the same configuration in hardware and software and time available to render the images outside the class hours); b) the university consists of three undergraduate courses related to audiovisual production (Cinema and Audiovisual course, Radio and TV course and Digital Media Communication course), thus increasing the possibility of a sufficient number of participants in the mini-course / activity of research.

In addition, the choice to develop the field research in Brazil instead of Portugal also happened because the proponent, despite being linked to the doctorate in the Portuguese university, is a professor at the Brazilian university, having, therefore, access and knowledge about the infrastructure besides the support of the institution.

In this context, although the students who participated in the experiment were native speakers of Portuguese, most of the audiovisual and CGI production software is already used in the English language, as well as the manuals of the video and lighting equipment used in the productions during the teaching activities.

Due to this common use that students of audiovisual courses established with the English language, and understanding that it is the most used language internationally, it was preferred for adoption in the prototype because it would allow its dissemination and use by teachers in an international context, and not in only countries adopting the Portuguese language.

5.3.5 License

The prototype was licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. It allows others to download and share the work if they assign the credit but cannot change or use it for commercial purposes.

5.3.6 Website

For the tool to meet some important characteristics to be classified conceptually as a digital learning object as advocated by authors such as Tarouco et al. (2014) and Braga (2015), it was necessary to create a website to house the tool and complement it, with informative items such as its metadata and instructional structure (information about the general and pedagogical goal of the tool, usage guidelines and instructions for teachers and students).

In this way, the website was created which, in addition to housing the tool and such instructional and metadata content, also presents complementary information about this doctoral research. It can be accessed at https://sites.google.com/campus.fct.unl.pt/digital-media-phd-website-avm.

5.3.7 Learning Object Repositories

Another important feature in the definition and conceptualization of a digital learning object according to several researchers in the area (Prata & Nascimento 2007, Penteado, Gluz & Galafassi 2013, Braga 2014, Braga 2015, Tarouco 2014, Tarouco, Fabre & Tamusiunas 2003) (Prata & Nascimento 2007, Penteado, Gluz & Galafassi 2013, Braga 2014, Braga 2015, Tarouco 2014, Tarouco, Fabre & Tamusiunas 2003) is the possibility of their sharing in repositories so that they can be accessed and used by other teachers.

In this way, in order to contemplate this conceptual and relevant element for the distribution and dissemination of the tool, after having passed several tests and finalizing its first version, it was submitted to appreciation in two international DLO repositories, Merlot Repository (Brinthaupt, Pilati & King 2008, pp. 240-245) and Open Educational Resources Commons (2008, p. 1).

After the evaluation of the tool by these repositories and approval and release for publication, it has been made available for access and is already cataloged in the respective search services and available for viewing, access, and sharing.

6. CONCLUSION

The theoretical and practical research carried out in references of the Design area and the most varied methods of evaluation and conception of Digital Learning Objects, evidenced the great amount and diversity of different methods and techniques for the design of a DLO. Moreover, it has been found that due to the wide diversity of types of DLOs that can be created for a wide range of purposes and areas of knowledge, it has not been possible to come up with a single, standardized method that can be recommended for design and development of any DLO.

That is, the research was based on the evaluation and understanding of the most diverse existing methods, to extract which attributes were the most common among the different methods already reported in theoretical references that address the conception of DLOs. Thus, the research sought not only to indicate the most relevant and essential attributes to aid in the design of a DLO but also to explain the method used, which was based on a meeting of these best qualities of various methods, which can serve as a reference. It is a departure for other teachers and enthusiasts looking to design their own DLOs to assist in their teaching activities, whether the tool is for blended-use or autonomous use.

Thus, it is believed that the research was useful in its survey, selection, and improvement of the most relevant attributes and repeatedly used by the best known and widespread methods in the area. Therefore, the research was positive in its intention to contribute to the reflections about the design techniques necessary for the development of a DLO, allowing to guide new investigations and creations of DLOs.

Besides, future publications may further expose the results of the DLO implementation designed in this research to contribute to other research fronts regarding the validation of DLO's.

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