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CONCEPTION, PROTOTYPING AND EVALUATION OF DIGITAL TOOL TO ASSIST IN THE TEACHING OF VISUAL EFFECTS WITH MATCH MOVING

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ABSTRACT

This article reports a case study in which a digital learning object (DLO) was developed to assist in pedagogical practice in higher education (in the audiovisual area) and presents the technical and theoretical stages of the tool development process (DLO) and its assessment.
The objective of the research was mainly to evaluate the pedagogical contribution of DLO through the perception of students who were subdivided into four groups, performed two practical exercises at different times and order, during a 60-hour course. Both exercises of the same complexity were performed without and with the aid of the digital tool.
Subsequently, the participants answered forms to be able to evaluate the tool, in addition to having their audiovisual products developed during the course/research been used for a blind analysis to infer qualitative gain at work due to possible time savings generated by the automation function of the tool.
In the end, it was found that the DLO tool was very well evaluated conceptually and considered relevant, differentiated, with credibility and high intention of use (among other metrics). The blind analysis showed that there was no qualitative difference due to the possible gain in time between the works developed with or without the aid of the 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.

It was defined as 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 in parentheses to indicate the theoretical reference base 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 - Description (Main Theoretical References)
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.

5.2.1 Prototyping Platforms

Preliminary research was carried out in search of prototyping platforms (sketch and model), where it is possible to program and design applications for mobile devices without the need to know programming languages, in addition to also making it possible to test them on various mobile devices and send them to app distribution stores 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). 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 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).

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.

The solution chosen 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".

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.

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 and the Number of Elements that the Prototype will support

Having defined the technologies to be used in the prototype, a study was carried out to select the variables to be used in the tool. As an example, we can mention: the standard lights, with 47 possible attributes for their creation and configuration, 11 were selected for use in the tool, in addition to the positioning and name data, reaching 15 attributes; the Physical Camera, which out of a total of 77 possible attributes (18 commons with other types of the camera added to another 59 specific attributes) were chosen 21 of these attributes, plus name, position, and angle of inclination, reaching 28 attributes. In this way, all the constituent elements of the tool went through a selection of the most relevant attributes to be used.

For this selection, in the first moment, the essential attributes for the correct configuration of the element were prioritized, so that it could present the same characteristics of the real elements present in the moment of shoot the film. In the 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. The attributes related to more specialized and refined configurations, whose function is more relevant in use in later stages, were left out.

At the end of the prototype production, after the effective tests, a total of 319 fields were used between the necessary fields to meet the attributes of all possible inputs of all possible elements, in addition to the fields required for navigability and programming.

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.

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. Although it is not possible to make them available in this article, they are available on the research website.

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

To meet various attributes and complement the tool's functionalities, some animations and static images were produced to assist in the understanding of some concepts of the tool. Others were collected on the web with their referred credits.

Hyperlinks were also used to websites with more detailed technical explanations of certain concepts, access to online tools to assist in specific calculations in the audiovisual area, such as unit conversion tools (lux, lumens, candela, watts) or for calculating the field of view (FOV) of the camera.

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.

Because of the frequent use of the English language in audiovisual production software's and the familiarity of higher education students with it (whether in Brazil or Portugal), in addition to the awareness that it is the most widely used language internationally, it was preferred for adoption in the prototype, as it will allow its dissemination and use in an international context, and not only in countries that adopt 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) 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. FINDINGS

6.1 Form - Product Concept

The first Form aimed at an analysis of the concept of the product, bringing the relevance, differentiation, credibility, and intention of use to be evaluated in a linear scale of zero to ten points by the respondents (Likert Scale or Décis) (Martins & Theóphilo 2017) besides other questions that used other scales for the answers.

For the representation of data analysis, it will be using the sum of the percentages of the first four items of the scale (Top 4: 7 to 10) and the sum of the percentages of the last four items of the scale (Bottom 4: 0 to 3).

In the four initial questions, the results were as follows:

Question 01: The participants evaluated the tool with high relevance for students of courses related to audiovisual production. With a Top 4 response rate of 92.8%, no negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean of the assigned scores, we arrive at the 9.14 assessment on the scale of zero to ten (standard deviation of 1.23).

Question 02: In the differentiation question, the participants considered the tool highly differentiated from others they might have already had contact with. With a Top 4 response rate of 92.8%, no negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean the value assigned to this question is 8.85 on the scale of zero to ten (standard deviation of 1.29).

Question 03: The tool was evaluated with high credibility by the participants. With a percentage of Top 4 responses of 85.8%, without negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean of the assigned scores, we arrive at the 8.5 evaluation on the scale of zero to ten (standard deviation of 1.69).

Question 04: On average the participants evaluated their intention to use the tool in a high mode. With a percentage of Top 4 responses of 85.7%, without negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean the value assigned to this question was 7.92 on the scale of zero to ten (standard deviation of 1.73).

For questions 05 and 06 a scale of zero to ten points was also used, but the value of the value itself was not used, but a representation where zero has the meaning of "totally disagree" and in the other opposite of the scale the value ten has the meaning of "I totally agree".

Question 05: "Learning, having competence and qualification to produce more elaborate visual effects (integration between real and virtual images in audiovisual) can improve my possibilities of insertion in the labor market". The participants agreed very strongly with the statement. With a Top 4 response rate of 99.9%, no negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean of the assigned scores, we arrive at the 9.57 assessment on the scale of zero to ten (standard deviation of 0.93).

Question 06: "Learning, competence, and qualification to produce more elaborate visual effects (integration between real and virtual images in audiovisual) allow me to have greater creative freedom in my audiovisual projects". The participants agreed very strongly with the statement. With a Top 4 response rate of 99.9%, no negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean of the assigned scores, we arrive at the 9.57 assessment on the scale of zero to ten (standard deviation of 0.93).

For question 07 a linear scale of zero to ten points was also used, however, the assignment of the value itself was not used, but a representation where zero has the meaning of "would not recommend with certainty" and in the other opposite of the scale the value ten has the meaning of "would recommend with certainty".

Question 07: Participants would highly recommend the tool to a colleague, relative or friend. With a Top 4 response rate of 92.8%, no negative evaluations (Bottom 4 = 0%). Using the simple arithmetic mean of the assigned scores, we arrive at the 9.0 assessment on the scale of zero to ten (standard deviation of 1.3). This question, however, is based on the Net Promoter Score (NPS) methodology used to measure public satisfaction and aims to assess how well the company or product is recommended by the so-called definitive question.

As the NPS value computed in the question was 64%, by the standard scale we can verify that the index is within the Quality Zone, something very good since it is not classified in the Critical Zone or in the Improvement Zone (where it would require interventions and adjustments, deeper and/or structural adjustments). In addition, it is also perceived that there is scope for the product to develop, in order to seek to fit into the Zone of Excellence in the future, using the information gathered in the next Forms for its improvement.

Question 08 of this first form was the only one that did not use a linear scale from zero to ten. When requesting a comparison between the concept seen from the created tool and what is currently on the market, a linear scale of one to five was used where one could choose between comparative statements.

In this last question of this first Form, no participant understood that the product (tool) is worse or much worse than what already exists today. Two participants 14.3% answered who is neither worse nor better than what already exists today, the rest, 85.7% answered that they understand that the concept of the product they saw is better (71.4%) or much better (14.3% %) than what already exists today.

6.2 Form - Relevance

To create this Form of relevance in the MaxDiff model, all 39 attributes created were used. All attributes were randomized by the MaxDiff survey application that was configurated to create 30 comparative questions with 4 attributes each question (application makes the statistical distribution of attributes to the questions). Students had to mark in each of the 30 questions on the form, which of the 4 features he considered the most and least relevant. The 30 questions were randomly presented to each student participating in the survey to avoid bias related to tiredness if it had a single order for presentation the questions. As a result, it was verified that the attributes selected as the most relevant attributes of the tool were (attributes/total average relevance): Efficiency/98.3; Technical functionality/96.0; Content quality/75.6; Utility/69.0; Coherence/68.5.

In this Form, in relation to statistical metrics, the mean value of the attributes was 42.7, the standard deviation was 25.4 and the adjustment, measured by the RLH (Root Likelihood) was 0.6962, considered to be good (this parameter varies between 0 and 1, the closer to 1, the better the adjustment - values above 0.6 are good). According to the calculations, the attributes to be valued were those that obtained in their total average of adequacy value above 68.1.

The average value of importance 42 (on a scale of 0-100) is due to the fact that there are attributes that are of little importance to the respondents, and that, therefore, have amounts close to 0, which translates into a high standard deviation (also due to the number of subjects).

6.3 Form - Adequacy

To create this Form of adequacy in the MaxDiff model, 16 attributes were selected among the 39 attributes created for the relevance Form. The ones that most appear in the various methods of evaluation of DLOs studied. These attributes were randomized by the MaxDiff survey application that was configurated to create 12 comparative questions with 4 attributes each question. Students had to mark in each of the 12 questions on the form, which of the 4 features he considered the most and least relevant. The 12 questions were randomly presented to each student participating in the survey to avoid bias related to tiredness if it had a single order for presentation the questions.

Although it was not possible to reach a larger number of subjects, which limits the analytical robustness, the research model presented good results. It was verified that the attributes selected as the most adequacy attributes of the tool were (attributes/total average relevance): Technical functionality/72.1; Pedagogical objectives/61.4; Utility/50.0; Help in learning/49.1.

In this Form, in relation to statistical metrics, 21.1 values were obtained, the standard deviation was 23.9 and the adjustment, measured by RLH (Root Likelihood), was 0.7630, considered to be good (this parameter varies between 0 and 1, the closer to 1, the better the adjustment - values above 0.6 are good). According to the calculations, the attributes to be valued were those that obtained in their total average of adequacy value above 45.

The average value of importance 21 (on a scale of 0-100) is due to the fact that there are attributes that have aspects that are not very suitable for the respondents, and therefore have amounts close to 0, which translates into a high standard deviation (also due to the number of subjects).

6.4 Crossing between Relevance and Adequacy

Crossing the data from the importance/relevance Form with the adequacy Form, it turns out that the tool has adequacy below the relevance in the most important attributes, which means that it must be improved. With the crossing, it is possible to infer that the attributes "Technical functionality", "Utility" and "Content quality" present statistically significant value for greater relevance than adequacy.

Finally, although the adequacy analysis has shown relatively low values, there are many aspects that can be improved from the relevance analysis. Effectively, by improving aspects with amounts over 60, for example, it may be possible to build a new version of the tool even better than the current one.

6.5 Development Research - Blind Analysis

At the end of the mini course, each participant delivered in a digital format their practical exercises developed during the course. These files were renamed and identified only by numbers, and all kinds of information (such as metadata) were deleted from the files so that authors could not be identified.

These studies were submitted for evaluation by 3 external evaluators to this research, two of them being undergraduate Brazilian professors responsible for disciplines related to audiovisual production, and an evaluator who, although not a teacher, works in the audiovisual area in the city of Lisbon, Portugal.

To grade the works, audiovisual technical criteria were used as lighting elements (color temperature, light type, light power, positioning, shadows), animation, movements, clipping masks, chroma-key quality. Also, with composition criteria such as the soundtrack, sound effects, montage. The main orientation was the degree of correspondence and verisimilitude between the images generated by computer graphics integrate with the real ones and the quality level of this integration.

After collecting the values (notes) attributed to the practical work by the three evaluators, no differences were observed between the use and non-use of the tool in the quality of the work developed. Although the statistical calculations also present this result, the simple arithmetic mean of the evaluations of the three evaluators allows inferring the non-significant difference between the situation between use or non-use in the final audiovisual product result.

7. CONCLUSION

The research presents collaborations in the investigation of the real contributions of the DLO in the pedagogical activity. The data obtained allow us to infer that the prototype developed successfully achieved its main objectives (technical and pedagogical), and can also be used outside the educational context by professionals or students graduating from courses in the area. In other words, according to the students' perception, the tool was competent to assist in the practical activities of the discipline.

The tool that was designed, tested and evaluated in the classroom, can be used free of charge by any teachers in the field by accessing it in the repositories of international learning objects in which it was deposited; in addition to having access to instructional information for its use in the classroom on the research website. Furthermore, research as a whole used free tools and have its codes (and formulas) open, so it can serve as a reference for other teachers to develop their own DLOs, based on theoretical and practical frameworks based on the pedagogical and design areas.

It is also believed that the work reached a conclusion similar to that other works such as Popovich that conclusion that “Educators can add this study to the growing body of research regarding the effectiveness of digital learning objects and other open education resources as effective learning supplements. (…) that digital learning objects can be employed to aid in student learning, (…)” (Popovich 2018).

As with research carried out with medical students for the teaching of radiology, he concluded that “The blended learning method has a significant impact on performance during testing compared to the traditional method. The implementation of DLOs that complement face-to-face education makes it possible to strengthen the teaching process with high levels of satisfaction, justifying the time and resources required for their design and production.” (Durán-Guerrero et al. 2019).

Finally, the differences found in the comparison between the forms of concept, relevance, and adequacy (all positive) when compared with the results of the blind analysis (which showed no qualitative gain or decrease in the results) indicate the future recommendation of attention to the methods, for clearly demonstrate that the Hawthorne effect does not influence the results. Further exploration of collaborative studies to provide comparative studies that go beyond case studies is also recommended.

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