Integrating Participatory and Interaction Design of an Authoring Tool for Learning Objects Involving a Multidisciplinary Team

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Abstract. Traditional computer use in educational environments does not ensure learning improvement. Consequently, there is a global effort to make and provide more effective and efficient use of new multimedia resources and learning environments. Learning Objects (LOs) are entities, digital or not, which can be used or referenced during teaching. However, multimedia authoring of LOs is still complex and time consuming. In this paper we present a novel process integrating participatory and interaction design which we adopted in the development of an authoring tool involving a multidisciplinary team. As result, this methodology is used in the development of Cacuriá, a multimedia authoring tool for teachers with little or no programming skills to create LOs.

Keywords: Authoring tool, mental-model, navigation/search design, participatory design, interaction design, learning objects.

1 Introduction

Teachers and students often make use of technologies that allow new ways of teaching and learning. Teaching has undergone many changes, and multimedia resources such as slideshows, videos, and games have been used in both distance and face-to-face education increasingly in recent times. Multimedia authoring environments can handle several multimedia resources, among which we find Learning Objects.

A Learning Object (LO) is defined as any entity, digital or not, that can be used, reused or referenced during a learning or training process supported by computer(s) [1] [2]. The main role of an LO is to act as a teaching resource, including specific media contents of a subject such as image, text, video and audio, all synchronized amongst themselves. Miller et al. have shown that LOs improve the quality of teaching and help to provide tutors with several facilitating tools [3].

In general, a multidisciplinary team is required to build an LO. Its development can be a complex, expensive, and time-consuming process. Software developers are required to make the source code. Designers help to provide a visual identity for distinct LOs. Education experts make and measure teaching goals. Furthermore, in the core of the team, there is the content specialist (e.g., teacher and tutor), who provides the subject to be taught.

It is interesting to compare the current scenario of development of LOs with content authoring on the Web. In the beginning, web pages were built almost exclusively by experts in markup languages and Internet protocols. Over time, the Web has been popularized and new jobs have been generated, for example, the web designer whose main role is to design and develop web pages. Currently, a wide range of content on the Web is created by non-developers [4], such as blogs, which can be made and managed by end users with no knowledge of a programming language for the Web. Other users (e.g., journalists and writers) create profiles in social networks containing texts, videos, pictures and different additional multimedia components. The support for end users to author content on the Web is arguably one of the reasons that explain its popularization [4].

Likewise, in the context of LO authoring, in many situations the content expert could make LOs using an authoring tool. Our aim is not to replace a multidisciplinary team, but to let the teacher build simpler or preliminary LOs directly. We acknowledge that, in some situations (e.g. company websites, content portals and enterprise search systems), a multidisciplinary team to create web pages is essential.

The purpose of this paper is to describe the application of an integrated Participatory and Interaction Design (PID) to the design of an authoring tool for learning objects involving a multidisciplinary team. In particular, we describe the development of a multimedia authoring tool names Cacuriá[1], which allows teachers to build interactive nonlinear LOs for the Web and Digital TV. Teachers do not need previous knowledge of software development when creating LOs with Cacuriá. Furthermore, teachers may specify temporal synchronism among multimedia objects (e.g., video, image, text) arranged in scenes. Cacuriá supports the creation of branching plotlines, allowing the viewers to watch only the parts of the LO they find relevant to them.

This paper is structured as follows. Section 2 describes the integrated Participatory and Interaction Design (PID). Section 3 describes its application to the development of the Cacuriá multimedia authoring tool. Lastly, Section 4 presents some final considerations.

2 Methodology

User participation in systems development is considered essential to gather usability requirements and avoid usability problems [6]. Participatory Interaction Design (PID) is considered an efficient way to describe user requirements [5]. We then chose to design our multimedia authoring tool using PID, which is a combination of Participatory Design (PD) [7] and Interaction Design (IxD) [8].

[1] Cacuriá is the name of a Brazilian dance that is popular in the state of Maranhão.

Participatory design (PD) is involves users throughout the design and development cycle, so they can provide expertise and participate in the design and implementation of computer-based systems [7]. Interaction Design (IxD) defines the structure and behavior of interactive systems aiming to facilitate human interactions [8]. Both approaches can be used not only in the computer science field, but also in contemporary design practices in other fields, such as service design. In this paper, we adopted the iterative interaction design process described by Roger et al. [9]. It consists of four main activities, illustrated in Figure 1: identify needs and requirements; design (generating ideas); interactive prototype construction; and evaluation.

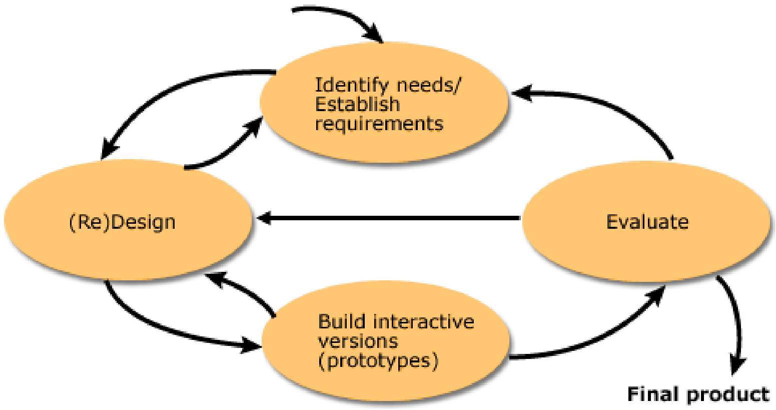


Fig. 1. Interaction design lifecycle [9].

To identify the key requirements for the authoring tool, we applied PD techniques such as focus group and card sorting. We also conducted paper prototyping sessions to gather further information about the user interface and interaction needs and wants. Next, we made a comparative analysis of LO authoring tools to evaluate whether they fulfilled the requirements identified using the PD techniques, as well as to improve our understanding of those requirements. The requirements gathered were thus enhanced and a multimedia authoring tool was proposed. Figure 2 presents the adopted PID process.

We can see two interaction lifecycles in the PID method. The first one is an iterative PD lifecycle [10]. The second one is the IxD lifecycle, formed by combining Interface Design, Implementation, and Evaluation. In both lifecycles we conduct activities of requirements gathering, design, prototyping, and evaluation, enhancing the designers' reflection about the final product. In this paper, we focus on the design phases; the evaluation phase and its lessons learned are detailed in [11].

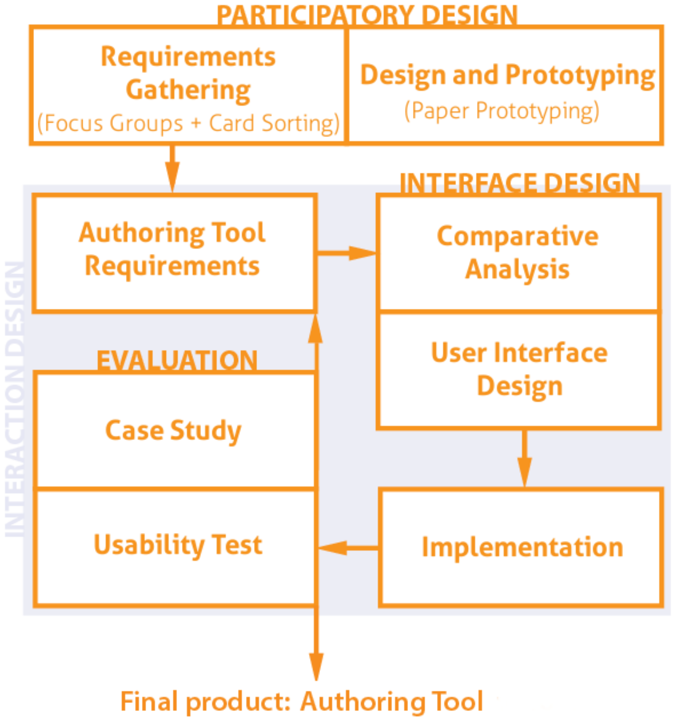


Fig. 2. Adopted PID process.

2.1 Participatory Design

The Participatory Design activities involved three techniques: focus group and card sorting, used in a meeting to gather requirements, and paper prototyping to evaluate concepts and clarify those requirements.

The participants of the Participatory Design sessions were stakeholders of the authoring tool. The sample selected consisted of 18 participants: teachers, undergraduate, and graduate students heterogeneously grouped in two sessions with 9 participants each. The participants were 3 undergraduate students and 5 Master's students in Design, 6 undergraduate students and 1 master's student in Computer Science, 2 high school teachers, and 1 pedagogue.

Requirements Gathering through Focus Group and Card Sorting Focus group is a qualitative technique that uncovers feelings, beliefs and opinions about the subject investigated through a kind of moderated collective interview, usually guided by a predefined script or list of topics [7]. In general, the aim of this technique is not to get the consensus of ideas, but to collect a range of opinions on a particular topic. The results are not analyzed as percentages or statistics and should not be generalized to a population [7]. Figure 3 illustrates how the technique was performed, keeping the participants anonymous.

Fig. 3. Focus group session.

Card sorting consists of writing topics on small cards, which are then distributed to a group of users (5 to 15 people) who must categorize them in a way that makes sense to them [12]. This technique promotes a better understanding of the users' mental models, i.e., how they think about the concepts in a given application domain.

The card sorting sessions began with a presentation of LOs to level the knowledge of the group. Then, participants were asked about the characteristics of a good LO, and what criteria an authoring tool should meet to create a good LO. At the end of the session, the participants reported the main features an authoring tool should have and grouped them in small paper cards (see Figure 4).

Fig. 4. Session of card sorting technique.

Design and Prototyping The next step in PD involved paper prototyping. A prototype can be seen as a draft design and aims to conduct tests for user interface evaluation. This kind of prototyping is considered low precision because it uses materials such as paper and cardboard, but tends to be simpler and faster to produce [13]. Its main goal is to evaluate designs early, thus helping to find problems before implementation starts.

The same participants of the previous activities were divided into 2 groups of 9 people. Each group was responsible for creating the user interface of a LO authoring tool based on the requirements obtained from the focus group and card sorting sessions (see Figure 5). After finishing the prototype, one member of each team presented it, along with its underlying design vision and the types of LOs the proposed authoring tool would support creating. Then, they demonstrated the LO creation process and the possibilities of interaction and system feedback through the user interface.

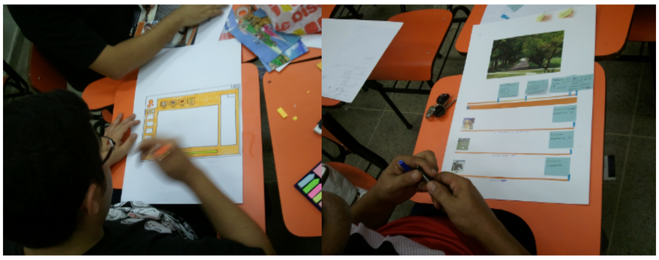


Fig. 5. Paper prototyping session.

2.2 Interface Design

The user interface was designed based on the concepts identified in the solutions obtained in the PD activities and on a comparative analysis.

Comparative Analysis We conducted a literature survey about authoring tools for LOs. Each tool was briefly described in a table and compared with the results obtained in the previous activities.

The purpose of analyzing similar authoring tools is to identify the characteristics of existing solutions and investigate the authoring approaches they support. Moreover, this activity also helped to find out whether existing tools already (partially) fulfilled the requirements gathered in the PD activities.

User Interface Design In order to satisfy the desired requirements for the tool, the user interface design was conceived considering both the results obtained in the paper prototyping activity and on user interfaces and system features present in the tools identified in the comparative analysis.

3 Results

The general results gathered with the research methodology have led to a number of requirements for a new multimedia authoring tool and a user interface metaphor based on scenes. In addition, methods, techniques, and technologies were chosen for implementing the authoring tool.

3.1 Participatory Design

Based on the techniques used in the PD activities, we specified a set of requirements for the design and implementation of our multimedia authoring tool.

Requirements Gathering We observed that the predefined script for the focus group yielded objective and relevant discussions. Most participants had some knowledge about LOs and had already used them to teach or to study.

Following the focus group script, participants started talking about what they knew about LOs and which models of learning objects they use in their teaching and learning processes. Most of them pointed out that the use of video and the possibility of the student to interact with the LO would improve and increase student focus on the LO content. An interesting point raised by the first group was the creation of a LO repository, in order to allow teachers be able to reference and reuse the content in LMSs (Learning Management Systems). However, for the stakeholders, sharing LOs in a repository raises copyright violation concerns.

Participants were unanimous in determining that an authoring tool should not require programming skills to build an LO. Both groups set as a requirement a minimalist interface, with few buttons and easy to use. Additionally, they considered that the tool should support the inclusion of media objects such as image, text, PDF and videos. Lastly, the second group reported that for a user to have a good experience and feel motivated to create LOs, the tool should be reliable and without errors.

Additional relevant information was obtained from the card sorting session. Table 1 shows an overview of the categorization made by the stakeholders. Some requirements for the design of authoring tools were obtained as a result of this phase.

Design and Prototyping The adopted PID process allowed the stakeholders to easily explore diverse user interface solutions by assembling and disassembling user interface prototypes. In addition, it allowed stakeholders to find problems and easily solve them by themselves. When a problem was found, they would redesign the user interface and test it again. During the prototype tool demonstration, the groups presented good ideas, features and a user interface which was easy to understand. The main results achieved were the interactive designs with fewer usability problems, which avoid later rework and thus save time in implementing the authoring tool.

Table 1. Results obtained from card sorting.

Interaction	Interactivity (does it help to learn?); Interaction (Student X Teacher); Interaction (Student X Student).
Ubiquity	Mobile Version; Desktop Version; Different Enviroments (In class X Distance Learning); Study Anywhere.
Engagement	Learning Curve (adjustment period); Choosing the moment to study; Abandonment, commitment, acceptance and withdrawal, lack of interest of the student; Demotivation of the student, content revision; Strategy to attract and engage.
Ethics	Content Copyright.
Reliability	Few errors; No error interrupts.
Usability	Minimalist aesthetic; Fewer buttons; Easy to use; Cover basic needs; Have a media Library with drag and drop functions; clean workspace; Timeline; Dynamic; Simple edition tools.
Resources	Power Point; Videos; 3D; Text; Slides; Quiz; Images; Tutorial; Animation; References; Movies and documentaries.
Functionalities	Remove; Download Content; Creation and edition tools; Insert image; Cut; Audio volume control; Resizing; Add subtitles; Navigation tools; Url links; Recording tool; Related images listing; Video tools; Text tools.

The first and the second group described minimalist interfaces. Both of them presented the video as the main media and the initial step for the creation of a LO. Another common decision was to use temporal and spatial views. The goal of the spatial view is to make it easy to position and scale the media object. Nevertheless, there were some differences in the temporal view. The first group made a “slide switch” in which each slide had a main video and the timeline referred to a video frame. Meanwhile, the second group created a single timeline referencing all videos of the LO. Timelines could contain markers (which participants called sync points). The first group proposed two kinds of markers (start and end) to show the temporal relationship among media (e.g., video, audio, text, and image), whereas the second group made just a start marker to represent the beginning of all videos.

The first group also defended the idea of having a library view. This view allows an author to add a media object to the project and then use it in the spatial view (for instance, via drag-and-drop interactions). This group also added a widgets concept to their user interface. The intention behind widgets is to allow authors to include in the LO extensions such as quiz, slideshow, and menu.

In general, both groups believed that the tool should have few buttons, be easy to use and allow the inclusion of different media objects and formats (image, audio, and text). A number of users with experience using video-editing tools pointed out the importance of a temporal view to have a better time control of media such as video and audio.

The paper prototyping technique helped to improve the understanding of the requirements collected in previous phases, by allowing participants to explore concrete solutions to meet and refine those requirements.

3.2 Interface Design

This section describes the user interface design resulting from the PD activities and the comparative analysis.

Comparative Analysis Several multimedia authoring tools for learning objects were found. The main ones were: CourseLab [15]; DITV-Learning [16]; eXe Learning [17]; HotPotatoes [18]; Microsoft LCDS [19]; MARKER [20]. Most of them follow the SCORM (Shareable Content Object Reference Model) reference model, which is a set of specifications defining a content aggregation model, a sequence model and a model for executing LOs on the Web [21].

The user interface of CourseLab [15] resembles Microsoft PowerPoint. It uses a WYSIWYG (What You See Is What You Get) approach in order to facilitate the creation of LOs by nondevelopers. The tool supports various file formats such as video, audio, text, Java applets and Flash. In addition to content structuring, it is possible to assign actions to objects, such as animations on a clickable image. However, it does not edit the source code of learning objects. The tool also allows the creation of interactive activities such as questions with single and multiple choices, true or false; sorting items; filling gaps in sentences; and linking items. Moreover, its contents can run on various LMS, such as Moodle, ATutor and Oracle iLearning.

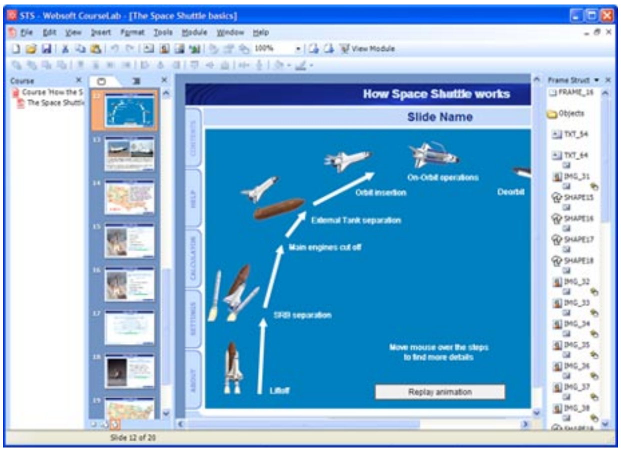
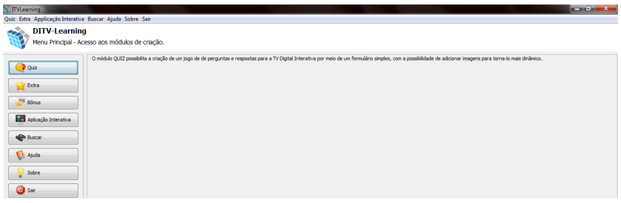


Fig. 6. CourseLab's user interface [15].

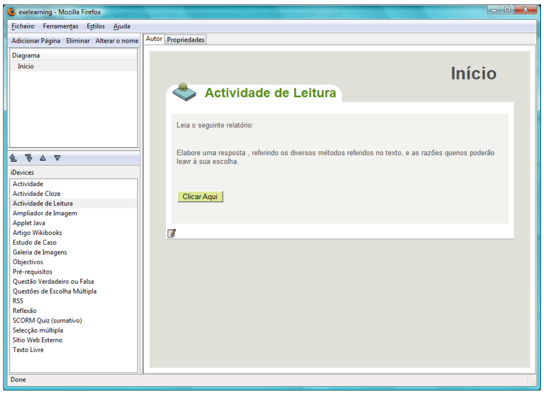
DITV-Learning [16] automates the creation of LOs for interactive TV by professionals who have little knowledge of programming. The tool supports various file formats of video, audio, image and text objects. DITV-Learning allows users to create LOs as a quiz, bonus (content in the form of slides), and extra (add-ons that can be triggered interactively during an application execution). The LO generated by the tool runs only on devices with the Ginga NCL middleware (more details about Ginga in Section 3.3).


ITVLearning
Quiz Extra Applicação Interativa Buscar Ajuda Sobre Sair
DITV-Learning
Menu Principal - Acesso aos módulos de criação.
Quiz
Extra
Bônus
Aplicação Interativa
Buscar
Ajuda
Sobre
Sair

O módulo QUIZ possibilita a criação de um jogo de de perguntas e respostas para a TV Digital Interativa por meio de um formulário simples, com a possibilidade de adicionar imagens para torna-lo mais dinâmico.

Fig. 7. DITV-Learning's user interface [16].

eXe Learning [17] is a Web-based tool for the creation of LOs in HTML, which can also be used in LMS. It provides interactive features to users as text reading, multiple choice questions, true or false questions, Java applets, youtube videos and Wikibooks articles. In the authoring tool there are seven editable templates, an LO that describes how to use the tool, iDevices creation and an HTML editor of LOs.



Leia o seguinte relatório:

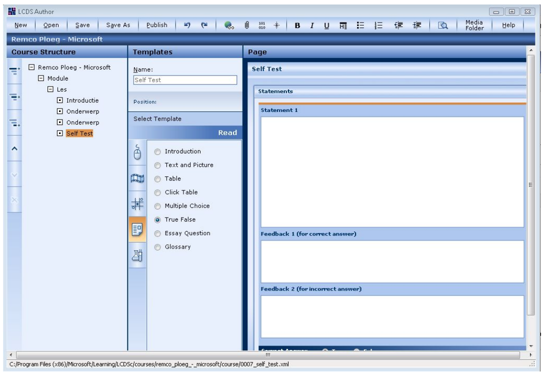
Elabore uma resposta , referindo os diversos métodos referidos no texto, e as razões quenos poderão leavr à sua escolha.

Fig. 8. eXe Learning's user interface [17].

Hot Potatoes [18] is a desktop tool designed for the production of interactive exercises in LMS, such as Moodle. It consists of five types of interactive exercises: quiz; fill the gaps; crosswords; matching columns; and sorting of words in the text. When you create an activity you can enter questions and answers, but you cannot use animations. The tool lets the user group several activities into a package.

Fig. 9. Hot Potatoes's user interface [18].

LCDS [19] is a Microsoft desktop tool for creating LOs. It includes templates for authoring LOs and a software manual in English. It supports various file types of text, images, and video objects. It allows the production of page sequences, but it does not allow to resize the page. The LO in HTML format generated by the LCDS does not follow the SCORM model and does not allow editing.



Name: Self Test

○ Introduction
○ Text and Picture
○ Table
○ Click Table
○ Multiple Choice
● True False
○ Essay Question
○ Glossary

C:/Program Files (x86)/Microsoft/Learning/LCDSc/courses/remco_ploeg_-_microsoft/course/0007_self_test.xml

Fig. 10. LCDS's user interface [19].

MARKER [20] is a desktop tool and, like DITV-Learning, it is intended for authoring LOs which can run on interactive TV with the Ginga NCL middleware embedded. It allows the user to create markers on the main video in order to replace them for other media objects (e.g., audio, video, image, text). The user can also define interactions related to those objects. For instance, pressing the blue button on the remote, an image can be resized, a video can be paused, etc.

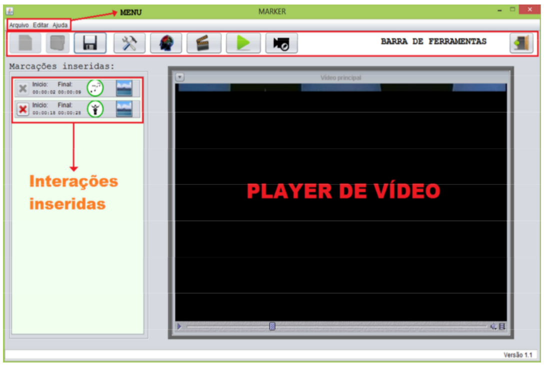


Fig. 11. MARKER's user interface [20].

As shown in Table 2, all these tools are aimed at creating LOs without requiring users to have programming skills. However, none of them fulfills all the requirements uncovered in the PD activities. This motivated the development of Cacuriá, a new multimedia authoring tool for creating LOs.

Table 2. Summary of LO authoring tools.

	CourseLab	DITV-Learning	eXe Learning	HotPotatoes	Microsoft LCDS	MARKER
Interactive Videos as LOs	x	x			x	x
Mobile Compatible LOs	x					
Desktop Multiplatform		x	x	x		x
Few Buttons (Minimalist)		x			x	x
Multimedia Content Manipulation (WYSIWYG)	x					
Non-Linear LOs	x		x		x	x
Timeline	x					x
Programing Knowledge Not-Required	x	x	x	x	x	x

User Interface Design The user interface was designed with six views to manage media, as seen in Figure 12. In the Menu View (1), users can add media, visualize the project, and publish the LO. In the Scenes View (2) users can add, remove, edit, and select a scene, templates, and automatic links among scenes. In the Layout View (3), users can view the position and size the media over time, as well as add, remove, and edit media. In the Temporal View (4), users can run the LO and manipulate the time of the scene, as well as view, move, and remove the temporal markers of each media in a scene. In the Feature View (5), users can visualize and edit the properties of the selected media. In the Library View (6), users can list, rename, and edit the order of media objects in the project.

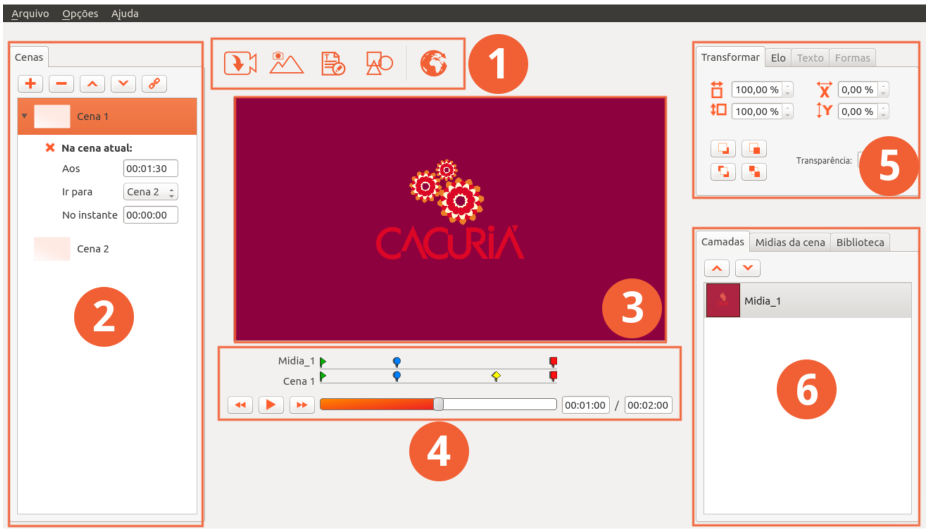


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Fig. 12. Cacuriá's user interface.

Cacuriá[2] is a WYSIWYG (What You See Is What You Get) tool, where all the viewed content and the one that is being modified resemble the final application generated by the tool. The tool does not require the user to have specific previous knowledge about the specification language used to develop interactive applications. This turns out to be quite useful for end users who do not have specific programming knowledge, but who are interested in creating LOs. It can also be useful for casual users, who do not want to spend too much time learning a language or technology to create LOs.

The abstraction adopted by the tool for creating LOs is based on the media synchronization in a composite node. This same abstraction is used in several tools [15, 22]. In this paper, the composite nodes are called *scenes*. Each scene is composed of one or more media objects (videos, image, text, and shapes) syn-

[2] Available at https://goo.gl/inxv1N

chronized with the timeline. In order to create interactive, non-linear content, the tool provides ways to navigate between scenes and to open additional content such as web pages, which are triggered by links anchored on certain media objects. The tool also features the use of *scene templates*, which predefine the position and size of media objects, leaving for the user only the work of choosing media objects that will be used in the template. Therefore, as shown in Table 3, Cacuriá covers all the requirements gathered in the PD activities.

Table 3. Requirements covered by Cacuriá tool.

	Cacuriá
Interactive Videos as LOS	x
Mobile Compatible LOs	x
Desktop Multiplatform	x
Few Buttons (Minimalist)	x
Multimedia Content Manipulation (WYSIWYG)	x
Non-Linear LOs	x
Timeline	x
Programing Knowledge Not-Required	x

3.3 Implementation

The authoring tool designed to create LOs for interactive TV and Web was named Cacuriá. It was developed using C++ and the Qt framework [23]. Qt allows the creation of multi-platform applications using the approach "write once, compile anywhere" [23], which enables the tool installation on Windows, Linux, and Mac OS.

In order to store all the information contained in the tool, a class called Document was created. This class provides a global access point of information for the other classes of the system. This class was modeled applying the Singleton and Observer design patterns [14]. The code architecture was designed using views. When a user interacts with a certain view, the other views are updated through a signal sent from Document, as Figure 13 shows.

Another important feature of Cacuriá is that it exports the interactive applications to either NCL (Nested Context Languages) [24] or HTML5 [25]. NCL is a language adopted by the ISDB-Tb (International Services for Digital Broadcast, Terrestrial Brazilian) for the specification of interactive applications in the declarative part of the Ginga middleware, as well as the ITU-T (International Telecommunication Union) recommendation for IPTV services. Meanwhile, HTML5 allows an LO to be displayed on the Web.

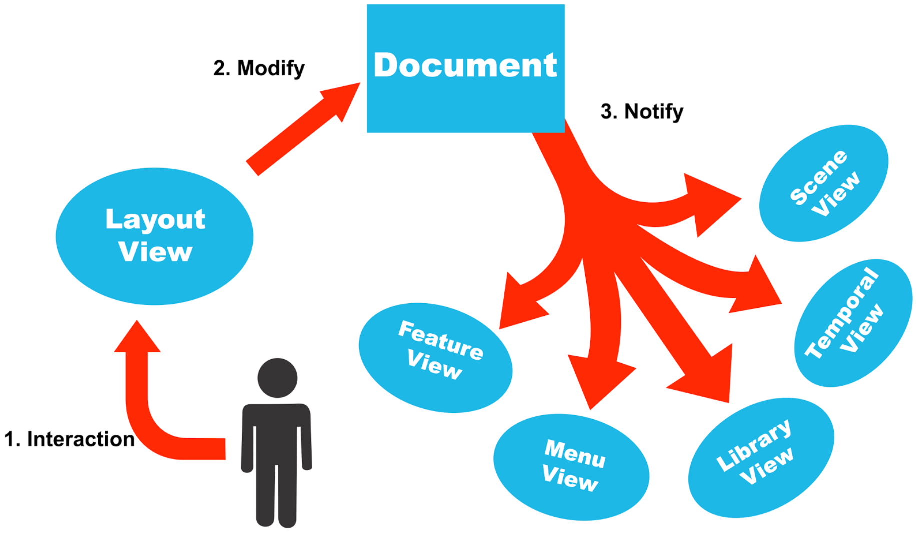

Fig. 13. Overview of the communication between the Document and the Views.

4 Final Considerations

This paper presented a Participatory and Interaction Design process for building multimedia authoring tools which includes the stakeholder as a central element in their design. The process allowed us to gather requirements and improved our understanding of user needs and mental models. Besides including users at the center of the design process, the process also incorporates mechanisms for iteratively evaluating and redesigning the prototypes to improve the product.

The process is exemplified in the development of the Cacuriá authoring tool. The tool allows teachers with little or no programming skills to create learning objects. Cacuriá can be used to create a wide variety of learning objects using a minimalist interface, a simple information storage structure and an abstraction based on scenes. In addition, the use of interactivity mechanisms enables the teacher to create applications adapted to the student needs.

The requirements gathered in our research can be reused by designers and developers of similar tools. Moreover, the techniques and methods described in this paper (e.g., paper prototyping, card sorting) can be used to support the design of other multimedia authoring tools.

Acknowledgments

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References

1. IEEE Learning Technology Standards Committee (LTSC). Draft standard for learning object metadata. IEEE Standard 1484.12.1 (2012)
2. Wiley, D. A.: Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In: D. A. Wiley (ed.), The instructional use of learning objects. http://reusability.org/read/chapters/wiley.doc (2000)
3. Miller, L., Soh, L., Samal, A., Nugent, G., Kupzyk, K., Masmaliyeva, L.: Evaluating the Use of Learning Objects in CS1. In: Proceedings of the 42nd ACM technical symposium on Computer science education (SIGCSE '11), pp. 57–62 (2012)
4. Paternò. F.: End user development: Survey of an emerging field for empowering people. ISRN Software Engineering, Hindawi Publishing Corporation (2013)
5. Martikainen, S., Ikävalko, P., Korpela, M.: Participatory interaction design in user requirements specification in healthcare. Studies in Health Technology and Informatics, 160:304–308, MEDINFO 2010 (2010)
6. ISO standard 9241
7. Simonsen, J., Robertson, T.: Routledge International Handbook of Participatory Design. Routledge (2012)
8. IXDA, http://www.ixda.org/
9. Rogers, Y., Sharp, H., Preece, J.: Interaction Design: Beyond Human-Computer Interaction. Wiley (2013)
10. Simonsen, J., Hertzum, M.: Sustained participatory design: Extending the iterative approach. Design issues, 25(3):10–21, MIT Press (2012)
11. Damasceno, A.L.B., Soares Neto, C.S., Barbosa, S.D.J.: Lessons Learned from Evaluating an Authoring Tool for Learning Objects. In: Proceedings of the International Conference on Human-Computer Interaction HCII 2017 (2017)
12. Nielsen, J.: Card Sorting: How Many Users to Test. http://www.nngroup.com/articles/card-sorting-how-many-users-to-test/ (2004)
13. Snyder, C.: Paper prototyping: The fast and easy way to design and refine user interfaces. Morgan Kaufmann (2003)
14. E. Gamma, R. Helm, R. Johnson, J. Vlissides and G. Booch.: *Design Patterns: Elements of Reusable Object-Oriented Software.* Addison-Wesley, 1994.
15. CourseLab, http://www.courselab.com
16. Sousa Neto, F., Bezerra, E., Dias, D.: ITV-Learning: a Prototype for Construction of Learning Objects for Interactive Digital Television. In: Proceedings of International Conference of the future of Education, pp. 486–490 (2012)
17. eXe Learning, http://www.exelearning.org
18. HotPotatoes, http://hotpot.uvic.ca
19. Microsoft LCDS. http://www.microsoft.com/learning/en-us/lcds-tool.aspx
20. Sousa, F., Bezerra, P., Soares, I.: MARKER: A Tool for Building Interactive Applications for T-Learning. In: Proceedings of 19th Brazilian Symposium on Multimedia and the Web (WebMedia '13), pp. 281–284 (2013)
21. Advanced Distributed Learning. Sharable Content Object Reference Model 2004 4th edition (2009)
22. Meixner, B., Siegel, B., Hölbling, G., Lehner, F., Kosch, H.: SIVA suite: authoring system and player for interactive non-linear videos. In: Proceedings of the 18th ACM International Conference on Multimedia (MM '10), pp. 1563–1566 (2010)

23. Summerfield, M., Blanchette, J.: C++ GUI Programming with Qt 4. Prentice Hall (2008)
24. Soares, L.F.G., Moreno, M., Soares Neto, C.S., Moreno, M.: Ginga-NCL: declarative middleware for multimedia IPTV services. In: IEEE Communications Magazine, vol. 48, no. 6, pp. 74–81. IEEE (2010)
25. W3C. HTML5. `http://www.w3.org/TR/html5/`