Keeping Digital Libraries Alive: Designing an Interactive Scientific Publication to Drive Demands of Scholars Based on Participatory Design

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Abstract. Digital libraries are one of the primary sources of sharing scientific knowledge. Presently, an article is located on the main interface of a digital library, which contains information about the publication, authorship, references, abstract, along with the indexed full text in PDF. However, how do scholars imagine the ideal design of this interface to be? What's more, which features could the library provide to enhance the scholar's reading experience and, consequently, the acquisition of knowledge? Along these lines, this study sought participatory design approaches to discuss and find interesting possibilities for an interactive scientific publication interface. A contribution to this endeavor is included in three consecutive steps: a participatory design workshop, a follow-up exercise, and a prototype to demonstrate designing solutions. Finally, it presents lessons learned about the interface that the scholars conceptualize, suggesting demands to be incorporated into publications as well as a discussion to drive changes regarding how to present and communicate scientific results.

Keywords: Participatory design · Digital library · Scientific publications

1 Introduction

Publishers related to digital libraries are still independently consulting scholars (potential users) to create solutions for their interfaces and services, not giving the user an opportunity to participate in the entire process. The problem is not prioritizing the stakeholder´s mental model, where ideas are being created and presented, but rather, the stakeholders themselves discussing social and political issues to identify problems and solutions. That is, space and relevance must be given to the scholar to debate and reach a solution for the present and future of digital libraries.

In this way, a case study previously presented solutions for the creation of interactive scientific publications interface, problematizing the lack of a closer and more participative relationship with the users to improve the achieved results [1]. Thus, the study

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has the goal of designing a novel interactive scientific publication interface to drive the scholars' demands based on participatory design, which is distinguished from other approaches in the field. The chosen methodology follows the notion that by engaging the scholar in the process, their knowledge is considered and applied to the design to identify the needs and find solid solutions.

The following section describes related work that goes through a quick contextualization and explores how participatory design can inform a series of insights and actions to achieve a design interface and discussion. We report our process in the development of a workshop and a follow-up exercise, resulting in a prototype; we detail the learning that took place through activities, observations through video recording as well as a discussion about solutions for interactive scientific publications.

2 Background and Related Work

Scientific content is evolving from a print-based format in the digital medium to a format that allows the possibilities offered by features from interactive interfaces, becoming available to digital libraries. In this way, the UI/UX design has a growing role in improving the interfaces of digital libraries. An example of related work is the ACM Digital Library [2], which has developed a set of projects to address immediate and future action for core functionality, content expansion, content organization/exposure, and customization. For this purpose, the ACM DL [2] in its methodology addresses workshops, and user feedback, demonstrating the importance of this study.

However, studies including advances in the creation of a novel interactive scientific publications do not usually incorporate the stakeholders into the designing process [1, 3–6]. There is a lapse in the importance of direct user involvement in the decision-making process, failing to include a deeper understanding of users' desires regarding the design of the imagined interface and its elements to increase engagement as well as improve the accessibility and consequently, the acquisition of scientific knowledge [1]. Nonetheless, digital libraries can benefit from the Participatory Design (PD) context to contribute directly to the needs and desires of the target audience.

We rely on previous work [7–17] to guide the design through changes to the scientific publication interface with a collection of design methods, including the user throughout the process. Therefore, the purpose of design is to engage researchers in activities in order to discover new ideas, priorities and flows for creating and redesigning interactive scientific publication interfaces in a more representative way. In this manner, we are inspired by the first two stages by Bødker et al. [16] and Steen [15] who describe and discuss tools and practices that support creativity and how they are part of design cooperation activities as in using the past to inform design and the curiosity that helps the researchers to empathize with others and their experiences.

Moreover, the participatory design approach employed by Ferati et al. [17] highlight the importance of creating the prototype with participants, dividing into two phases of creation, paper and digital, which provide enhancements regarding its look and feel. In addition, Ferati et al. [17] demonstrate the impact of the workshop of the future [10, 11] to engage participants in developing future plans, and we carry those thoughts to the possible future of scientific publications.

The methodology challenges the assumptions already made about feature improvements to be applied in publications [1, 3–6], as well as obtains various views of the dialogue among participants [7, 13]. According to Sanoff [8], an important point in the participatory process is learning through increased awareness of a problem and encouraging dialogue, debate, and collaboration. Thus, participation can be seen as the researcher´s shared decisions made for the scientific community that determine the quality and direction of scientific publication utilization.

3 Methods

There are three main steps of the study: (A) participatory design workshop, (B) follow-up exercise and (C) prototype development. The steps are integrated to infuse the concern of the participant into the design process (see Sect. 4). The workshop integrates steps adapted from the future workshop model [10, 11], which has multiple phases: preparation, critique, fantasy and implementation, each with its own practices. Through the execution of methodologies, such as the workshop of the future [10, 11] we are involving participants in multiple phases, raising political issues to scientific making and improving their communication as well as generating abundant ideas and emerging different suggestions. Consecutively, the follow-up exercise collects the results of the sketches and the decisions from the implementation phase for a second decision stage with the participants. At this stage, the interface elements and their perceived functionalities are decided. Based on the previous steps, a prototype was developed.

4 Participant's Concern Infused into the Design Process

The participatory design that we seek derives from earlier concepts in which the user is not only included in the design, but mainly "intervenes in situations of conflict through developing more democratic processes" [9], providing both a theoretical logic and concrete methods to engage users. Therefore, we recognize PD as a process with many approaches and techniques. Thus, in the following subsections, we present the participatory design workshop, second-stage exercise, and finally, the prototype.

4.1 Workshop Conducted and Its Results

Preparation. The participants were recruited by a survey; the workshop methods, the schedule, and their rules were settled as well as the location and the materials used.

Recruitment. Fifteen participants were recruited, nine of whom attended the workshop. The participants (N = 55.6% female) learned the pre-requisites of the survey sent by email, they are researchers from different areas, ranging in age from 20 to 42, who frequently access scientific articles (more than 2 times a week). Moreover, all participants have read or browsed interactive publishing, of which 66.7% prefer interactive articles and 33.3% indicate that both (print-based or interactive) have their benefits.

Method. The method reliability was established using references [7–17]. Research questions were built to define the theme addressed during the dynamics: (a) What are the characteristics of the current interfaces of publications in different areas of knowledge experienced by scholars? (b) What characteristics should the interface provide to increase the engagement and accessibility of scientific information to the scholar? (c) What are the useful interactive multimedia resources and how should they be structured in the interface?

Flow and Agenda. A presentation was made for the participants to understand the flow of tasks and their contribution. The definition of the context covered understanding input materials and the intended outcomes, including the setup of the event agenda. The flow of tasks is related to the critique and fantasy phases in which the participants integrate the development of PD with their experiences and innovative ideas in a critical way to be discussed in a group. Following, we proposed video recording while the participants engaged in the workshop (the workshop lasted about 60 min).

Critique. In the second phase, we addressed the issuing brief. At first, publishing in digital libraries was contextualized in the current scenario to be critiqued and discussed by the group. Then, examples of different types of scientific publications were presented, as well as other types of rich publications to brainstorm ideas in a critical way. Participants took notes on goals they need to achieve with their design solutions.

Fantasy. In the third phase, we provided materials, such as a sheet of paper and colored felt pens, suggesting participants to draw the results of the brainstorm and encouraging creativity. Here, the participants were advised to sketch an interactive interface with features to enhance the reading experience, and the acquisition of knowledge. The imaginative warm-up was developed in this phase. We offered prompts to influence sketching with the perspective of future possibilities for the interface structure (Fig. 1).

Fig. 1. Different structures were presented: Newick tree, circular points and content blocks.

Sketching. Individually, participants sketched their interface mental model which functionalities that attended their demands as scholars who search, share, read, analyze, and understand data in scientific publications (Fig. 2). In groups of three, participants shared and discussed the promising ideas to be transformed as a possible and attainable core. Then, the participants were ready to share the viable ideas and the characteristics of their strengths with the whole group. The dynamic was performed through the participants'

speech when they expressed the logic of the interface drawn. Hence, the desirable characteristics that the interface must assume in order to meet the user's needs are understood in a more complete and detailed way.

Implementation. In the fourth phase, the realizable ideas were checked, analyzed and evaluated by what concerns their practicability. The process occurred in an interactive way with mediation between designers and participants. Common features in the sketches were marked with the same colored stickers. The patterns were selected to be incorporated into the design decisions and implemented in the prototype. In this manner, markers in orange were related to the title and abstract with video/audio, the purple color was for grouped media, yellow for collapsible structure, and pink for the navigation map (Fig. 2). Additionally, green represented media icons and blue for visual references presented interactively. Patterns of the structure were evaluated and decided according to group consensus, e.g., a media preview at the top, percentage viewed with a checkbox per section, and connecting points of conclusion to other important parts.

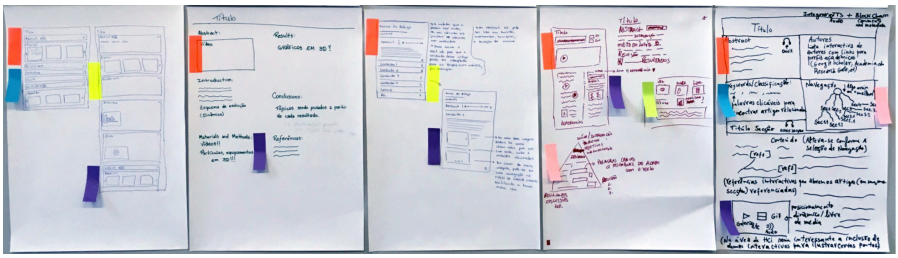

Fig. 2. Sketches made by participants being checked, analyzed and evaluated. (Color figure online)

4.2 Follow-Up Exercise

A follow-up exercise occurred as an activity related to the iconological outcomes and functionalities drawn and described in the sketches of the scholars with equal patterns observed in the implementation phase that generated ten icons presented in this phase (see Fig. 3). Thus, the study is justified by the participants' evaluation, perceiving the relevance of a more in-depth study related to the icons, their symbology, and functionalities that directly affect the user interaction with the scientific publication.

Participants' mental model [18] related to the features in a symbolic way with icons, visually simplifying the interface [19], especially for small screens as in mobile phones. The activity gave users the ability to express their decisions, allowing adjustments to the set of icons proposed in the design [17]. Dynamics of the exercise were made in two parts. The first part contained two options: participants could choose one of the three symbolic representations of the icon or draw a better representation. The second part included the participants writing a justification for the selection made and decided the functionality of the referenced symbol (Fig. 3). After data collection, an evaluation of the participants' inferences was administered, and the results were presented in a prototype to incite the possible solutions for the interactive publication interface.

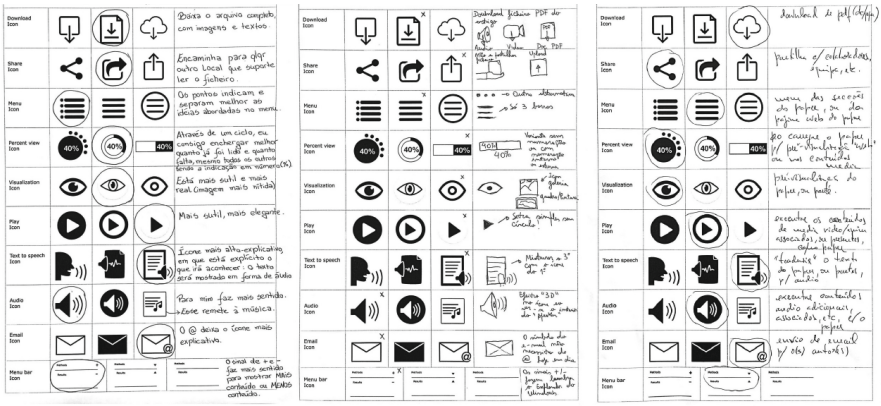

Fig. 3. Design decisions expressed in the exercises carried out by three participants.

4.3 Prototype Development

The prototype proposal was created to illustrate its generative role in enabling the participants to reflect on their design activities in a completely democratic process [11, 20]. Consequently, the prototype demonstrates the interface idealized by the scholars, after the problem discussion, sketching, analysis, and evaluation of commonalities to avoid ambiguity. Additionally, achieving assimilation of the functionalities and interactions related to the icons designed and justified by the participants.

The prototype was generated in Adobe XD to present the results achieved in the participatory steps above, demonstrating how the design works with the highest possible fidelity (Fig. 4). Providing enhancements regarding its visual quality, the prototype also explores the responsive design [21] as a solution for the mobile interface.

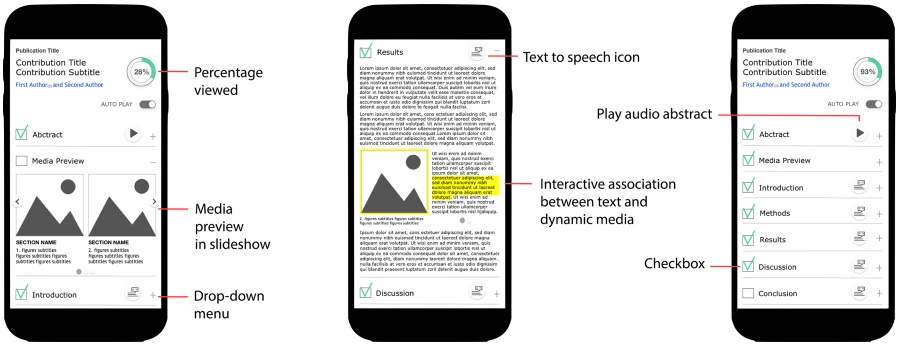

Fig. 4. Illustration of a few prototype screens.

Therefore, the prototype manifests design goals, building upon scholars' ideas to reveal important patterns in different aspects of novel interactive scientific publishing interfaces. For example, the screens shown in Fig. 4 illustrate the media preview in a

slideshow, the dynamic images next to the text highlights the parts that are referenced, the drop-down menu simplifies the sections visually and provides intuitive interaction, among others. Likewise, the iconological solutions and their functions (text to speech, play audio abstract, percentage viewed and checkbox) from the follow-up exercise.

5 Lessons Learned

Following the requirement gathering phase using participatory design methods with a workshop and another follow-up exercise, we generated a prototype as a visualization of the results. Thus, we were ready to discuss the user interface design possibilities that the scholars idealize with interactive features. This section explores the ability of language-use to reveal user preferences [7, 13], allowing the lessons learned to drive demands to be incorporated into projects of interactive scientific publications interfaces.

5.1 Characteristics of the Interface to Provide Increased Engagement and Accessibility of Scientific Information to Scholars

A drop-down menu was an interesting concept thought of and sketched by participants, reflected in the organization of the publication structure to attend various screen sizes, as in mobile devices. Consequently, the reader has a view of the entire article, quickly checking the noteworthy sections. As summarized by [P4] and [P9] "*as the user is reading, it opens the content-related tab.*". The entire view of the article can be used for the responsive design solutions in any publication.

In order to create a media access mechanism, the participants reflected on a media preview in the over-part of the interface during the group discussion. The idea is that the media is always visible, so the reader could go directly to a graphic, image or video indexed in the article. In this way, the structure of interactive multimedia features is discussed to provide engagement and accessibility. In their sketches, participants indicated the desire for the integration and association of static and dynamic media in an interactive way with the entire article, as to be able to articulate the knowledge structure in a more engaging way, to make deeper visual connections to the results. Examples of this are *"topics being pulled from each result in the conclusions"* [P7], *"dynamic positioning/ free of media"* [P8], *"interactive visualization of the data"* [P6] and, *"Combine figures or graphics in a pop-up window animated by tabs to compare results"* [P1].

In such a way, by designing solutions for video and audio, participants entered into a consensus that an extended video/audio abstract containing parts of the introduction and conclusion would be extremely useful. A video "abstract" is valid in publications that can summarize the content in a schematic/illustrative way in a few minutes. At present, the audio "abstract" is more functional when the scholar does not necessarily need visual support to understand the issue of the article, as also clarified by [P2] *"… you can be doing something else while listening to the article…*". Therefore, an audio is, in general, easier to make than video regarding media creation.

5.2 Icons as the Input of Interaction and Functionalities

The icons imagined and designed by the participants produce contributions directly for their interaction with the interface. The connection between symbol and functionality for the action should be intuitive and fast as well as summarize and highlight, explain actions and aid navigation [19]. Besides, the icons achieve the interactions between textual and media content, e.g., a text to speech icon was created to suppress the researchers' need for listening to the article sections independently by skipping irrelevant information (see Fig. 4). This symbol was the most laborious in order to find an appropriate metaphor, and in this way, the recommendations are labels and tutorials.

A percentage icon of the publication section view is created from an idea of a participant, shared in the group and discussed as reported by [P5] *"I think this part of checking the sections that I've read and seen, the percentage of what I have yet to read and what I have read is very useful, especially when we are looking at many papers at the same time."*. Thus, this functionality is given relevance to be incorporated into the user interface design of interactive scientific publications.

6 Discussion

At the beginning of the workshop, participants' main criticism was that there are few interactive publications, arriving at a consensus that PDF is still the format most seen in their research areas. Some publications are still heavily anchored to the printed format as discussed by [P7] *"… engineering articles rarely combine interactive tools or other features to make a publication more engaging."* But as [P6] argues, *"I have already seen some websites and journals that provide the PDF content in HTML with some enrichments such as a pop-up in the references."* For them, this is already considered a paradigm shift from the print format in the digital medium to an interactive one.

Reinforcing the arguments of the participants, as reported by Coper and Kalantzis, the information revolution did not produce a significant social or epistemic change in a publishing technology context [22]. This argument by the authors presents the PDF format as an example, which makes journal articles accessible. Nevertheless, they are only reproductions of the production processes and social relations of the printed journal [22], although PDF has been supporting the integration of three-dimensional (3D), audio and video content on-the-page since June 2008 [23].

The gradual evolution of electronic journals, the fourth phase described in 1995 by Lancaster [24], in which there would be the creation of an entirely new publication, based on the exploitation and use of multimodality and hypermedia, has not yet happened. The way information is structured still represents a paradigm for the understanding of the subject addressed and consequently, generation of knowledge. The participants, as researchers and article readers, comprehend that they are communicating complex results (difficult-to-illustrate and hard to record their mind's eye). Hence, the workshop sustained participants discussing mechanisms to make the publication more dynamic and interactive as well as support a quick content uptake (see in Sect. 4).

The absence of a policy for adding to submissions of audio or video abstract as a mechanism for a quick understanding of the article content is one matter discussed by participants. This type of media benefits not only the reader, but also the authors, as it

can influence the visibility of the metrics of access, citation, and download of the article. Bringing the discussion to current reality, some publications suggest sending videos as in Plos One [25]. However, it is not mandatory, which is an issue according to the participants. Furthermore, the interactive multimedia features are not an integral part of the understanding process or tool to summarize the content within the publication.

The importance of dynamic content within the publications are also clarified to illustrate experiments as well as practical projects in different areas of knowledge. Taking as an example, [P3] reports *"I read many articles that relate to graphic design and they have publications with 3D images. I think it would be interesting … if we could also interact with this three-dimensional model … instead of just seeing a static image."*. Trying to close this gap, some scholars, as authors, add links to demonstrations in personal pages or platforms like *YouTube* in their articles. This fact occurs because of the lack of this capacity within the publication. Furthermore, the connection between text and illustrative material is broken by the separation of content on different interfaces, which can result in an overload of cognitive efforts by the user when trying to compare outcomes. As a consequence, users feel lost and frustrated.

7 Conclusions, Limitations and Further Work

Our experiences showed that designing a new interactive scientific publishing to address the scholars' demands based on participatory design pose a richness and variety of outcome lessons to improve the interface and critically discuss the need for changes in scientific communication. The search for an improved way to present research results in a digital and interactive age cannot happen without the direct interaction of scholars, as the continuous and interactive design process of dialogue involving stakeholders really demonstrates the needs of what the scientific publication will become.

One of the limitations of this study is that the evaluation of the prototype has not yet occurred, which will take place in the next stage. Thus, the stakeholders themselves are participating in important decisions about functionalities, and the visual aspects of the project should guarantee better results as the prototype will be tested. Future work will be based on the evaluation of the prototype according to satisfaction index and self-reported engagement. These improvements will be incorporated, and a new assessment will be generated to understand if there is greater cognitive engagement (assessment using eye tracking) and knowledge.

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