Designing Design Resources: From Contents to Tools

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Abstract. This paper presents the design process and implementation of a design knowledge repository. In recent years, design evolved into a broad discipline with a large application field. From an educational point of view, this design expansion brings the need to rebuild design contents and resources for both practitioners and learners. We designed and developed a repository of design resources. The design process followed a user-centered design approach, taking into account different types of users with learning needs. Design contents were analyzed taking into account the new challenges and disciplines of design and the educational needs of practitioners and learners. Three main types of design contents were identified and also the need to provide tools instead of simply contents, that is, up-to-date and actionable resources that, at the same time, lead to reflection and critical thinking. These tools were arranged into a toolbox, a knowledge repository that became a toolkit. The toolkit provides an adaptable navigation system that allows either direct access or exploration of the available tools.

Keywords: Design · Education · Learning contents · Learning resources · User-centered design

1 Introduction

Design is a ubiquitous human activity used in every problem-solving situation. Over the years, especially in the second half of the 19th century, the design has been closely linked to industrial development and associated with artifact production in a variety of fields [1]. This association between design and product development has led to usually focus on the application rather than addressing to design itself. Indeed, this is one of the reasons why generally design has not been deeply studied like a research field. In recent years design has suffered a significant evolution that led to redefine the discipline and the designer role. This evolution has displaced the focus from products to ideas, people and experiences. Consequently, new design disciplines have appeared such as design thinking, service design, co-design or open design [2]. Despite this expansion and diversification, there is a shared set of common elements in the design practice, especially on asking questions, solving problems and the transversality of their methods and techniques. This evolution brings the need to update the design knowledge field and the related contents for learners and practitioners to use.

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Currently, the availability of design content and resources is very scattered. Most design content and resources are created and shared within the context of a design discipline such as product design, graphic design, interaction design or learning design. This makes difficult to extend the use of these contents to other practitioners or learners who often come from other design disciplines or even from other fields. Consequently, these very focused design contents often become isolated and obsolete in a short time.

In addition to that, most of the design contents are published either in a traditional manner through books or by short specific publications, mostly online, oriented to the different design communities. This way of distributing and accessing contents makes difficult for the design practitioners to keep updated on the knowledge of the field and to learn new competencies and skills in order to explore new possibilities of problem-solving as well as making and to be able to apply it to projects from diverse fields [1]. As a response, the design community started developing design resources under the tool perspective, promoting the aggregation of contents through toolboxes. Also, most of design toolkits are addressed to practitioners. Therefore, there is an opportunity for providing an open-ended organization of design resources for both practitioners and design students. Both user profiles are learners, since practitioners are lifelong learners that face the new challenges of the design disciplines and, in a more autonomous way, they try to be up-to-date on their discipline. From an educational point of view, students and practitioners need to learn and be updated with actionable contents and resources. Therefore, instead of one dimensional and static contents there is a need for dynamic tools, fostering among other things reflection and critical thinking as key professional competencies for the 21th century. This proposal aims to provide users access to educational design resources in several ways from direct access to exploration, using a navigational system to empower teachers and learners [3]. In addition to that, we want to provide different levels of depth for each content, depending on the educational needs of each user.

This paper is organized as follows; the state of the art of learning content repositories is presented in Sect. 2. Section 3 presents our approach to design and develop design learning contents. The implementation and evaluation of our proposal are presented in Sect. 4. Finally, in Sect. 5, the conclusions, limitations and future work are discussed.

2 The State of the Art

The design of digital knowledge repositories requires a deeper understanding of the expected users: teachers and learners. Consequently, it is necessary to get a first-hand look to students learning and to know how these repositories can support them in their learning processes. Focusing on the students learning, during the industrial age, the students were expected to learn specific contents through explicit directions from the teachers, emphasizing the compliant understanding in concordance with the external and professional expectations [4].

Over the last decades, design education has changed, becoming more flexible and student-centered. These changes not only imply a different point of view of how to involve students during the education design, but it has also changed the learning goals: from understanding learning contents to acquiring professional competencies and skills. In this regard, Samavedham [5] particularly emphasizes the relevance of the creative and critical skills within the professional competencies for the 21st century. Therefore, any learning implementation should aim to improve these students' skills. One way to improve them is through Problem-Based Learning (PBL) learning environments [6]. In this scenario, students are expected to resolve unknown problems in a dynamic, critic and collaborative way by informed decisions making [7]. This process is self-directed by the learner, who, by implication, get more autonomy in his/her own learning process. Furthermore, during this process, they are expected to show what they have learned along the process of problem-solving [8]. In this context, sometimes also known as Student-Centered Learning (SCL), students become the very center of their learning process in an open-ended learning environment [9]. Glasgow emphasizes in [10] the importance of the learner autonomy in SCL, where "students learn to decide what they need to know to find success within the class and educational format". Thus, learners decide the key components of their own learning process in order to acquire their individual or collective goals. [9]. It could be understood as a creative work where learners have to navigate the problem space and iterate solutions to achieve the result, which is not necessarily known at the outset of the process. Even though, the role of the lecturer should not be underestimated because they have an important purpose: acting as a learning facilitator by encouraging learners to explore their learning process [11] and providing students with the adequate scaffolding in order to build it.

Focusing on the resources used during the learning processes, Wiley [12] defines the learning objects as "any digital asset which can be used to enable teaching and learning". It is commonly accepted that the digital education resources created by teachers and learners are key components of the knowledge assets in the education communities [13–15], especially in e-learning settings. In this way, there are a variety of initiatives that reinforce the importance of providing educational resources to the educational community in order to reuse and share them through Learning Objects Repositories (LORs) [16, 17]. It should be noted that these educational resources are produced in diverse contexts. Rodes-Paragarino et al. [18] analyzing the use of repositories in digital education highlight the Kooper identification of the three levels of reuse of educational resources: (a) first level, where the creator of the resource reuses it, (b) second level, where a member of the same community reuses it and (c) third level, when it is reused by an outside community member [19]. Thus, this use of educational resources emphasizes the need to develop a digital educational repository [18] in order to provide access to the community and allow them to reuse these educational resources. In this way, some research outcomes show an evolution of the discussion on labeling these educational resources in order to be found and used by others, as well as the debate on how to label the "whole learning experience" facilitated by these resources in order to be transferred to other learning environments [20]. With the aim to create and share open educational resources, some learning initiatives have been presented in the last years. These initiatives enable users to use and explore these educational resources [21] through digital repositories.

Although this work focuses on digital repositories, it is important to keep in mind that the knowledge dissemination has not always needed the use of the technology. In this way, books had been a way to disseminate knowledge to the community who had access to them since the 17th century. Although, it has to be emphasized that due to the increment of Internet use during the late 20th century some other typologies of educational content had emerged. Hence, it is amply studied how this had changed the nature of resources and information [22]. Wikis are an example of these supports where the community can find, create and share knowledge. In the same way, specific databases and publications are also an example of content dissemination. Focusing on technology-based repositories, there are several specific software that allow users to create and adapt the repository to their needs. Examples of these educational repositories are MERLOT, CAREO, Paloma, Edua and Ariadne LOR. One of the most used software is Dspace, especially in academic communities [23]. This software allows users to recollect and tag digital content to be shared with their community. Note that it is not enough to just publish the contents in the repositories to facilitate their reuse. Accordingly, adding metadata to describe the content is very valuable. In this way, most repository software allows to tag content with the use of metadata. Nevertheless, the metadata must be well defined and completed and existing related work shows that the use of metadata in learning repositories is diverse and heterogeneous [24]. Some studies underline that the current metadata model for learning resources in repositories difficulties for general and universal re-use of contents by users or software pieces [24–26].

Providing tools to learners instead of contents stored in repositories has the potential of fostering exploration-oriented learning. In this sense, Resnick et al. outlined in [27] learning tools requirements: (a) Easy to try things out, and backtrack if it is needed; (b) Make clear to the user what can be done and (c) Pleasurable and fun to use. In this line, Clemente and Tschimmel [28] demonstrated the effectivity of implementing a toolkit in order to improve the students' performance enhancement. The design community has begun to channel the solution providing its members with design tools through the use of toolkits. In the case presented in this work, and taking these design toolkits as an example, it is necessary to adopt this solution to an educational purpose.

2.1 Design Knowledge Repositories

Currently, there are some design-themed repositories aimed to provide contents in a tool-oriented approach. These repositories are usually called toolkits. It is worth to mention that most of the analyzed design toolkits aim to provide contents and tools to design practitioners (Table 1).

Most of the design toolkits provide a predefined classification of the content according to the creators' criteria. This predefined classification can be seen as parallelism with the direct instruction learning where the instructors provide the content classified by their own criteria (sometimes based on external requirements) [29]. At the same time, only a few of them allow users to filter the results through a filter system. It should also be noted that most of these design toolkits are designed as action-oriented. It means that the content is provided by guides or booklets that facilitate the users to take action.

Table 1. Analysis of design toolkit's main features and contents

Toolkit	Content	Classification system	Filters
AC4D Design Library	Design methods and tools	Process phases and type of content	–
Data visualisation Catalogue	Data visualizations methods	Alphabetical or by function	–
Design-led research toolkit	Design tools and methods	Process phases and alphabetical order	–
DIY	Design tools and Methods	Purpose	–
D.P.D	Design principles		–
Dubberly Design Office	Design models	Projects	–
Ideos' DesignKit	Mindsets, methods and case studies	Process phases	–
Hi Toolbox	Methods and activities	Energizers, Innovation, Self-leadership, action and team	Time available and group members
High Resolution	Product design and design thinking	Chronological classification	–
Medialab Amsterdam	Design and research methods	Alphabetical	Purpose and time available
Project of how	Creative methods	Exercises, generate ideas, group dynamics, select ideas and structure projects	Time available and group members
Service Design Toolkit	Methodology of service design	Templates types	–
Usability.gov	Methods, templates and guides	Methods, resources, guides	–

This overview underlines the importance to provide a toolkit, to the design community, with design tools that allow explorative navigation and also with direct access to resources like the use of filters. In addition, there is a need to facilitate the share and re-use of educational resources. Furthermore, in this work, providing tools in the local language, Catalan and Spanish, was also an incentive, since most design tools are only available in English.

3 The UOC Design Toolkit

This work takes place at the Universitat Oberta de Catalunya (UOC, Open University of Catalonia). It is a fully online higher education institution with a community of more than 58,000 students and more than 3,100 teachers. Teaching and learning mainly take place in a virtual learning environment that integrates learning contents, asynchronous communication, academic services and interaction with teachers and peers. Blaschke [30] underlines that the main audience of distance learning is mature adult leaders. This is the case of UOC students, 68,87% of whom are older than 25 years old and 28,61% older than 35 years old. Moreover, this learner profile is not a full-time student, thus, it is important to offer them a good learning experience by providing all the components of the virtual learning environment. Lifelong learners have autonomy in their own learning process [30]. Furthermore, their personal life takes place in their educational field, due to the learning process occurs as a result of the learner personal experiences [31], and the process is adjusted to these experiences [32]. This self-control of the process facilitates learners to identify their needs and learning goals. Consequently, it affects the way they plan their learning process and the interactions with the virtual learning environment.

3.1 Design Process and Methodology

This work followed a user-centered design approach based on the principles of ISO 9241-210 human-centered design process [33]: understand and specify the context of use; specify the user requirements in sufficient detail to drive the design; produce design solutions which meet these requirements and conduct user-centred evaluations of these design solutions and modify the design taking account of the results. From a research point of view, an Action Research Methodology (ARM) [34] was followed, which emphasizes consecutive iterations, being modified accordingly on the experience of the previous iterations. Furthermore, this cyclical nature of the ARM has strong resemblances with the user-centered design process [35]. Thus, this work presents the results of the first process iteration and evaluation.

The first phase of the work focused on understanding the context, gathering information and defining the users. Since we focused on an educational context we needed to collect information about learners and teachers and the educational requirements.

With this purpose, the first project iteration was focused on understanding the UOC teachers' needs related to design contents. We conducted 8 face-to-face interviews with lecturers involved in learning courses where the Design Toolkit could be applied. In these interviews, they pointed out the need to improve the existing learning materials and transform them to more actionable content but including reflection and critical thinking. In addition to that, the need to easily access and navigate resources was identified. Learners should be able to explore the models, principles, and methods of design and create their own point of view about how they relate to one another and how they fit within a design process. Also, the need to find easy ways to update the contents was underlined. Finally, the need for an easy to access platform or repository was identified, that is, that students from different courses were able to explore the same learning resources in different ways and that alumni and design practitioners were able

to access it as an open resource. The information obtained through the interviews was complemented with the outcome of the literature review, considering both design and learning science fields. During the research, the need for providing an interoperable and modular platform that allows easily to update the contents has been reinforced. As a result, the following findings were identified: unify scattered resources; easy updates of the contents; provide both direct an exploratory navigation system; provide different levels of contents depending on the students' needs and easily share the resources. Also, in order to foster exploratory learning, the need to provide design tools instead of design contents was identified.

3.2 Conceptualization and Design

The definition of the toolkit included several functionalities which were really important for improving the students' and teachers' experience in terms of developing and accessing design learning resources. Digital resources to be used within educational communities need to be organized, managed, shared and reused effectively [36]. Following the dimensions proposed by Mor et al. [37], conceptualization and design of each one of these dimensions had been done: users, content, and environment.

Regarding the first dimension, we noticed how challenging it is to define and implement a platform to be used both by individuals and a group of students [38]. In this case, the toolkit was designed to be used by different profiles: learners and lecturers. But it is mandatory to have a deeper view of each profile. On the one hand, learner profiles were subdivided, taking also into consideration the life-long learners (practitioners). On the other hand, the lecturers (teachers) who, in the UOC case, are both academics and practitioners.

The second dimension is the content and, therefore, design contents were analyzed according to the new challenges and disciplines of design and the educational needs of students and practitioners as life-long learners. This analysis, together with the analysis of the main design toolkits presented in Sect. 2.1 and the findings identified in Sect. 3.1, lead to the identification of three main types of design contents: models, methods, and principles [39]. In addition to that, we identified also the convenience of offering a toolkit that is action-oriented, providing practical step-by-step instructions through guides and, at the same time, cards (Fig. 1) for reflection and critical thinking, instead of providing just contents (Table 2). Even though this distinction was done in the type of content, it was decided to bring them together in one layout. Therefore, the step-by-step guides are accessible through links in the cards addressing the same content. Thus, the toolkit allows us to create decision-making systems that can provide a theoretical overview of the contents or can be a point of reference for decision making [40]. Furthermore, it was decided to provide external resources for each content that allow users to go in depth in the knowledge. These external resources offer real examples of each content, providing an overview of the practical appliance, and references to research publications, bringing the user closer to the academic world. This approach enabled a step forward towards a toolkit for educational purposes. In addition to that, the organization of the content through cards and guides allows two levels of navigation, that is, two levels of depth per content depending on the educational requirements for each user. Laurillard et al. pointed in [41] that the technology must be appropriated for

its context of use and must have to add value to the learning process and enable the learners to achieve the learning outcomes. In this sense, a modular organization was designed to allow learner and practitioners to use these resources in their own context of learning and practice, integrating these resources in their own learning environment.

Fig. 1. User Journey card with access to the step-by-step guide

Table 2. Type of contents provided in UOCs Design Toolkit

Learning depth	Objective	Learning
Cards	Reflection and critical thinking	Design
Guides	Action oriented	Tasks

As already mentioned, one of the big challenges identified during the interviews was the need to provide a platform that allows the easy updating of the contents. That was the reason for choosing Wordpress as the CMS to build the platform since it provides simple mechanisms and interfaces to upload and update contents.

The third dimension was the environment. In this way, based on the previously identified requirements, we designed a toolkit that allows users to access resources in several ways: direct access, filtered access, and exploration. For example, users can either directly access a tool if they know which one they need, or they can access by filtering tools (Fig. 2) or they can explore the available tools in order to identify the one that best matches their needs. We designed a navigational system to empower teachers and learners [3], giving them autonomy of use [42]. The designed navigational system allows: (a) to use the educational resources in different teaching programs with similar learning goals but with different levels of depth; (b) to access learning resources to solve learning tasks; (c) to explore learning resources as a way to enhance learner's responsibility and autonomy. In this way, it should be noted that, from a constructivism perspective, students construct knowledge and skills and organize their understanding through interactions with the environment [43].

Fig. 2. Design toolkit filter options

4 Implementation and Evaluation

The Design Toolkit was developed as a research project at Universitat Oberta de Catalunya (UOC). It was used and evaluated in several courses and learning programs: Interaction Design course from the Digital Design and Creation Degree, Human-Computer Interaction course from the Computer Engineering Degree and User-Centered Design course from the User Experience Design Postgraduate. Also, the UOC Design Toolkit is available as an open source learning resource for anyone to access, explore and learn.

In order to have evidence about the usage and satisfaction of the Design Toolkit collected data with different approaches: interviews with users, a questionnaire sent to students and usage data collected by a web analytics application.

A questionnaire was sent to the students enrolled in two editions of the previously mentioned courses and a set 170 answers were obtained. The questionnaire addressed questions about the main design decisions of the toolkit. Catalan and Spanish versions of the same questionnaire where developed since UOC has both Catalan and Spanish speaking students. In order to process and analyze the answers, the collected data were merged into one database. According to the answers provided by the students, the implementation of the Design Toolkit seems to be successfully. As shown below, most

of the students pointed out that Design Toolkit was useful for their academic and extra-academic activities. In this way, the students had to answer if they agreed that the design toolkit contents were useful to do the subject activities. From the 170 total responses, 82% of them answered they agree or strongly agree with that. Learners were also asked if the Design Toolkit contents were directly related to the contents they need to learn in order to follow the subject were the toolkit was proposed. From the totality of the answers, 78% of them agree or strongly agree that the content was aligned. Regarding the content, we asked learners if they thought this format was more suitable than the traditional one (see Fig. 3), 62% of them agree or strongly agree that the improvement provided by the Design Toolkit was beneficial to their goals.

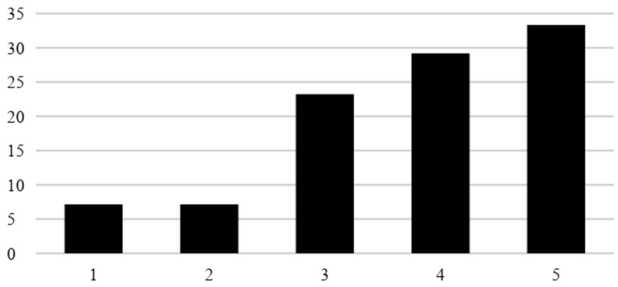

Fig. 3. Answers for the question "I think that the format provided by the Design Toolkit is better than the traditional format to present the contents" (5 indicates *strongly agree* and 1 *fully disagree*)

As pointed above in this work, exploratory navigation is a key factor for successful learnings. Thus, learners were asked if they used the Design Toolkit in an exploratory way. Of the totality of responses, 61% of them agree or very agree that the content had been useful for their extra studies activities (see Fig. 4).

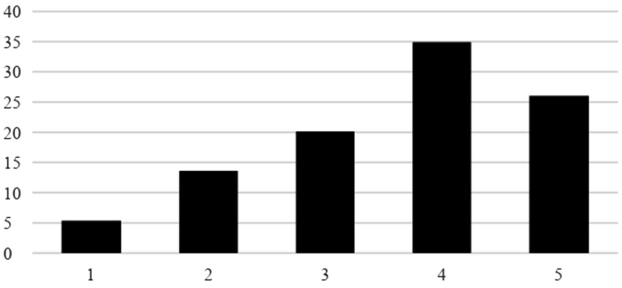

Fig. 4. Answers for the question "I explored the contents provided by the Design Toolkit further than the strictly asked by the subject" (5 indicates *strongly agree* and 1 *fully disagree*)

In this way, the data provided by Google Analytics shows that the guides have a 45% exit rate. This means 55% of the users that visit the guides continue exploring other pages of the Design Toolkit.

Apart from the questions related to learners' satisfaction with the implementation of the toolkit, we added some questions regarding the perception of the whole system and the navigation system. Regarding this last aspect, more than 63% of students say they see clearly the difference between guides and cards. Moreover, more than 66% of the students underline the usefulness of the separation between cards and the guidelines. Asking students about the navigation system and the filters, from the total of the answers, the 64% affirm they agree or strongly agree about the utility of the navigation system and the filers (Fig. 5).

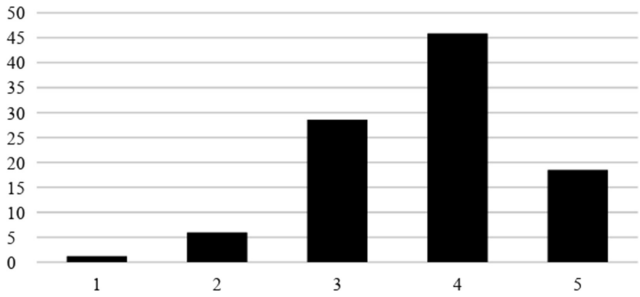

Fig. 5. Answers for the question "The navigation system and the filters provided by the Design Toolkit are clear and intuitive" (5 indicates *strongly agree* and 1 *fully disagree*)

Beside quantitative results gathered in the survey, qualitative results have been collected through questions with an open answer. We asked for proposals to improve the Design Toolkit, the implementation, and the contents. The most relevant outcome is the proposal to enable the PDF download of the guidelines provided by the Design Toolkit. Currently, this information is only available through the online platform and it is not presented in a printable way.

In this part of the first iteration phase, we also conducted three semi-structured interviews with UOC lecturers who had used the Design Toolkit in their class. In this way, the interview started with a set of questions related to the main goal of the interview: to know their satisfaction with the use of the Design Toolkit. All the responders were very satisfied with the UOC Design Toolkit and they expressed they will keep using the toolkit as a learning resource as well as a professional tool. Regarding the use of the toolkit they made, all the interviewed participants used the toolkit beyond the academic activity, making use of it in their non-academic professional tasks: "I have used the toolkit in professional projects to define the phases of the process we had to follow". This use beyond academic activity is also referred by students who, as shown in Fig. 4, said they used the toolkit in non-academic activities.

Asked about what they liked the most of the Design Toolkit, there were different answers. P1 said she liked to find a lot of design tools in the same place. P2 answered she liked the facility to integrate the tool content: "due to the modular classification of the content it is very easy to use it in different activities like a puzzle of knowledge".

P3 emphasized the filter system: “it allows me to find what I need very quickly”. About the students’ use of the toolkit, the responders said that “In addition to the use of the toolkit they (students) had to make to carry out the proposed activities, they explored the toolkit”. This is actually what the students responded at the questionnaire (shown in Fig. 4). P2 referred that “some of those questions whose content were provided by the toolkit had better results than whose contents were provided by traditional resources”. This is in line with the position sustained by Clemente and Tschimmel [28] and the responses of the students questionnaire shown in Fig. 4.

The last part of the semi-structured interview focused on obtaining suggestions for improvement to be taken into consideration in the next iteration phase. In one hand, P1 said “the usability of the toolkit needs to be improved, we must lead by example” and highlighted the need to “allow teachers to update content or add some case of study”. On the other hand, P2 said she would like to “merge this toolkit resources with other UOC’s toolkits (about interaction and art)”.

5 Conclusions and Future Work

This paper provides a successful design and implementation of a Design Toolkit. On the one hand, it fulfills the requirements identified for educational design resources and content available on the web. On the other hand, the developed and deployed platform enables the compilation and update of the design content on an easy and intuitive way. Moreover, the implemented format to show the content, based on cards and guidelines, and the navigation structure, allows the adaptation of the platform to the specific needs of the students depending on the activity they are performing: an exploratory search or an action-based use. The results enable to conclude that the platform has provided students the opportunity to have an active behavior through the use of an educational design toolkit [40], acquiring greater autonomy in their learning process [3].

As shown by the results obtained through the research, most of the students were satisfied with the contents and format provided by the Design Toolkit. However, due to the qualitative questions, we had some feedback that shows us several opportunities for improvement, such as the possibility provided by the platform to download the guidelines as a PDF file, as well as the convenience to increase the amount of content.

As a future work, the navigation system has to be analyzed and, if needed, re-designed in order to improve the user experience with the toolkit. As part of the iterative process proposed in the methodology section, future works and improvements of the platform will be considered in future iterations. All the research provided in this manuscript can be considered as the first iteration that will be followed by incoming ones, improving the usefulness and intuitiveness of the Design Toolkit.

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