Visualizing Deliberation and Design Rationale: A Case Study in the OpenDesign Platform

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Abstract. The open phenomenon coming from the free-software movement has gained several fields, including services, digital and physical products. Nevertheless, some authors point out the limited availability of supporting methods and online tools to face the challenges of the distributed collaboration of volunteers with diverse backgrounds and motivations. In this paper, we present the OpenDesign Platform and its potential to support distributed co-creation. A case study conducted with 22 participants attending a Conference in Organizational Semiotics illustrates their use of the platform to clarify the tensions and ideas towards the conception of a community-driven solution to a given design challenge. Results of their participation through the platform analyzed through graphical representations based on concepts of the Actor-Network Theory provided a visual representation of the network constituted by both the participants and the artifacts (boundary objects). These analyses, corroborated by the perception of the participants on their use of the platform, have shown the effectiveness of the OpenDesign Platform to afford online deliberation and communicate elements of the design rationale between participants. The QUID tool, used for the network visualization, revealed its representational power as an instrument for visualization and analysis. Further studies include investigating how the integration of the visualization tool into the OpenDesign platform may increase awareness of other's contributions during the (open) design process.

Keywords: Open phenomena · Open design · Open source · Online deliberation · Design rationale · Organizational semiotics · Actor-network theory · Participatory design

1 Introduction

The open phenomenon to systems design comes from the free-software movement and got spread over several fields including open data, open science, open governance, to name a few. Its origin goes back to the 1970 decade, with the political movement that occurred in reaction to the proprietarization of software source code, chaired by Stallman through the 'GNU Project' [27]. The open-source software, as defined by Warger [32], p.18 "an approach to software development and intellectual property in which program code is available to all participants and can be modified by any of them", focuses

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on the process of software code development and intellectual property. Since then, the open concept has been widened to reach other domains, including the broad cycle of product design [5].

Open design, in its broader sense, has been pointed out as promising and disruptive, although acknowledged as a phenomenon that has been yet little studied by the scientific community [5]. One of the main reasons for this effort seems to be the democratization of design; design here referring to physical as well as digital products, and services. The motivations of stakeholders to get involved in open initiatives range from ideological to the direct and indirect benefits perceived by participants. In this sense, the open phenomenon shares some principles and can learn from Participatory Design (PD) practices and related issues [26]. An example of this match is the user's role bringing his/her expertise to the design process, going beyond the object-for-money trade relation to other forms of contributions in the process and product of design. The tradition of participatory design is to ensure that end users are involved in the design process bringing the tacit and contextual knowledge to help shape design toward the most meaningful solution [26]. However, changes in information and communication technology, consumer culture, communities of interest, manufacturing processes, economies, and global markets have brought new opportunities to extend this tradition [16]. As stated by Frauenberger et al. [10], PD practices must be extended to increase the democratization of technology design, allowing a broader range of stakeholders to participate in the design process. Frauenberger et al. [10] propose to understand this movement through strategies such as scale and dialectics. Scale asks for ways to extend PD reach without giving up on its core qualities. Dialectics is about creating and maintaining spaces for constructive conflict by networking and linking with other stakeholders, organizations and domains. These demands pose difficulties and challenges for PD practitioners and researchers to conduct practices synchronously and in the same geographical place.

Achieving larger scale and improved dialectic requires tools that, on the one hand, afford creative and collaborative behavior, fostering the participation of anyone who feels affected by the proposed construct. On the other hand, such tools should avoid excessive or inadequate actions, such as having the voice monopolized by someone. Moreover, access for anyone to join the discussion at any point in time must be assured. Online Deliberation - OD - tools address the issues related to the online discussion process, helping participants to clarify a subject, by separating pros and cons arguments and opinions from each participant [17], equalizing biases and promoting awareness of points of view. However, used in isolation they lack support for more focused actions such as those needed in contexts of design, in which a group of people is creating something (an artifact, a concept, a system) together.

The Socially Aware Design – SAwD – design model [2] is a theoretical and methodological framework rooted on Participatory Design [26], Universal Design [30] and Organizational Semiotics [20] approaches. Its goal is to allow a collective construction of meaning, encompassing the diverse point of views from people involved and affected by the design of an information system or a digital artifact. The convergence of opinions and objectives occurs through a series of the so-called Semio-Participatory workshops, in-place activities conducted in face-to-face meetings where discussion and expression of all interested parties are promoted and mediated. Buchdid et al. [7] illustrates the

SAwD in a work involving the situational context of designing iDTV applications as a new object in the production chain of a Brazilian broadcasting TV organization. The work, which lasted seven months, aimed to develop an iDTV application for the TdG (*Terra da Gente*) TV show. A group of 10 interested parties from both within and outside the organization took part in the Semio-Participatory workshops and co-design activities. While that work illustrates the situated aspects of SAwD inside the organization, we wonder how it could gain scale, maintaining discussion around the main artifacts used in the synchronous and face-to-face meetings.

The OpenDesign project[1] was proposed to scale the SAwD, maintaining its structure and boundary objects, while also inspired by the Open Source (OS) philosophy. The OS phenomenon has provided a number of high quality software products, gathering and coordinating efforts from people with different skills and from different places. The OpenDesign main idea is to bring the same type of collaborative phenomenon to the activities that precede coding. The project's objective is to formalize a community-driven design process for interactive system design and to provide tools for its accomplishment. In the context of this project, a web platform was developed, intended to enable the Semio-Participatory workshops from SAwD to be carried out in asynchronous and distributed scenarios. One of the products of the OpenDesign Project is the OpenDesign platform, a web-based system enabling a community of participants the experience in open design.

In this paper, we investigate the importance of deliberation and design rationale in the (open) design process, through the use of the OpenDesign Platform in a case study conducted with participants of a Conference Summer School [25]. The platform we are addressing in this work can be seen as a purposeful social technology, where participants voluntarily interact towards a shared design goal, starting from the early stages of clarifying a design problem, by identifying the interested parties, and anticipating their potential issues regarding a prospective design solution. By 'open' we mean a design process that allows contribution of the volunteers to the product design since its conception, not only in a prototyping stage. The process is supported by well-established methods and tools, materialised in an actual online system: the OpenDesign platform and its artifacts (boundary objects).

The contributions of the work can be summarized as: 1. the presentation of a platform for open design, its architecture and main artifacts, including its deliberation and rationale aspects; 2. A case study revealing a preliminary use of the OpenDesign Platform; 3. A graphical instrument of visualization based on the Actor-Network Theory, for analysis of the platform use. This investigation advances our previous work [11] by further discussing the association network of participants and their contributions (boundary objects), highlighting the connectedness of their participation and the intersubjective relation of participants while contributing through the platform. Also, we further describe the platform architecture that enabled such co-creation to take place. Thus, this extended version reflects the new content also with a new structure for the text. The paper is organized as follows: In Sect. 2 we present the background and related work context. Then, in Sect. 3 we present an overview of the OpenDesign Platform, including its architecture and technological aspects, and its boundary objects. A case

[1] https://opendesign.ic.unicamp.br.

study on the Platform Usage follows in Sect. 4, with discussion on the main results. The final section concludes pointing out further work.

2 Background and Related Work

Bonvoisin et al. [6] argue that the spread of ICT and cheap low-size production tools like 3D-printers led to the community-based and open source development of physical products. This innovative organization of product development (open design) offers a great opportunity for continuous improvement of products as well as a potential for product innovation and, in consequence, incubation of new businesses. The authors also point out the limited availability of supporting methods and online tools for helping to face the organizational challenges raised by distributed collaboration of non-experts, non-professional and non-contractually engaged volunteers. They claim that online collaborative platforms are still needed with special features to build and keep the community active, providing mechanisms for the convergence of the design process, for knowledge management, and for supporting co-creation. Those features would be essential to the rise of open design.

In the tradition of PD, some efforts have been conducted with social technologies to increase people's participation regarding information production, publication, and sharing [13]. Hargreaves and Robertson [14] propose the use of social technologies (Skype video calls, screen sharing and email) to allow discussions between researchers and participants who are remotely located, and prototyping activities to occur at a distance. The interaction among participants is structured in regular cycles of reflective discussion and prototype modification. While social technologies are participatory by their nature as they require and depend on people's involvement to take shape, they also have drawbacks. For instance, regarding power, it is not clear who exactly benefits from people's participation, how to value participation without exploitation. Problems with privacy, ownership, deletion and sharing of personal information might be some issues raised when developing participatory systems. Bringing a participatory approach to the design of such systems is critical to ensure that people have the ability to negotiate, control and understand the implications of participation as they evolve [12].

In a study on the open design state of the art review, Boisseau et al. [5] illustrate that the subject of open design of products started in the early 2000s and is still a growing phenomenon. They have shown that the limited number of published papers suggests the concept has not spread over traditional design communities yet, still being restricted to a few research groups. Drawing on the design science approach, they argue that the subject that designers have to address is to provide a *plan* based on a *gap* (a design problem), through the development of a solution. Three elements are proposed to describe the product design process: a) the phases and activities that constitute the process, b) the boundary objects that constitute the information formalized and carried from one phase to the next one, and c) the participants (or stakeholders) taking part in activities of the design process. We should notice that the boundary objects are used for sharing a common understanding of the solution being constructed among the participants and that the plan is the final boundary object.

Fischer [9] studied design communities and identified types of common barriers they must cope with in order to work together: spatial (across distance), temporal (across time), conceptual (across different communities of practice), and technological (between persons and artifacts). For spatial barriers, it is straightforward to propose the use of computer-mediated communication as a solution. On the temporal domain, he stresses that "long-term collaboration requires that present-day designers be aware of the rationale behind decisions that shaped the artifact, and aware of information about possible alternatives that were considered but not implemented" [15, p. 155]. Conceptual barriers must be overcome by humans serving as knowledge brokers and by integrating diversity, making all voices to be heard. Overcoming the technological barriers depends on approximating people and technological artifacts and this approximation can be facilitated through their involvement in the design process itself.

Several attempts have already been made to provide a distributed platform for online collaborative design. Heintz et al. [15] searched for tools to support such tasks, and analyzed six applications:

- GABBEH [23] mimics paper prototyping by enabling users to comment on the current design by drawing with a software tool, but its technical requirements made it too restricted.
- DisCo [31] supports distributed PD sessions, but was not publicly available for use at the time of this study.
- Appotate (appotate.com) brings together different stakeholders, allowing them to give feedback on a prototype.
- MarkUp (markup.io) allows the user to draw and write on a website; however, it does not offer a structured way to store and retrieve this feedback.
- MyBalsamiq (mybalsamiq.com) mock-up software offers a wide range of common interface elements to create feedback on prototypes.
- Webklipper (webklipper.com) is an online application that enables the user to annotate websites and share the results.

Most of the mentioned tools mimic paper prototyping and enable users to comment on the current design. Most of them focus on the support for sharing the artifact being built - a prototype or a mock-up, for instance. They also propose a tool that, beyond the already found features, provides a like/dislike heatmap and enhanced interactivity.

More recently, tools such as UXPin (www.uxpin.com), Figma (www.figma.com) and Proto.io (www.proto.io) became available online as solutions for collaborative design. As a common feature, they provide real time editing of prototypes for all members of a team of designers, allowing the addition of comments and keeping the change history. Similarly to the tools studied by Heintz et al. [15], their focus is mostly on how the final product will look like or behave, and participation and deliberation occurs over an already materialised mockup. However, a collaborative, geographically sparse, culturally diverse design process asks for tools that allow the convergence of opinions and concepts also about what is being designed, for what purposes, uses and contexts, and who will be involved in its lifecycle.

Bjögvinsson et al. [4] discussed that a fundamental challenge for designers and the design community is a change of focus from designing objects to designing sociomaterial assemblies, which encompass heterogeneity of perspectives among actors who

engage in attempts to align their conflicting objects of design. In their proposal, the role of non-human participants in the design process, such as prototypes, mock-ups, models, and diagrams is to act as "presenters" of the evolving object of design, supporting communication and participation in the design process, potentially binding different participants together.

We agree with Bonvoisin et al. [6] in acknowledging the concept of open design as a significant phenomenon, supported by trends in contemporary digital technology and organization, which faces significant challenges of interest for several scientific disciplines. For example, they cite (p. 3): "*understanding the dynamics of online communities, developing motivation models for contributors, identifying business models that allow to create sustainable economic value with open source products, understanding the decision processes in horizontal work organizations, clarifying legal issues of intellectual property, identifying ways to ensure and validate product quality, liability and safety"*, among others.

As for the open design of products proposed by Boisseau et al. [5] in the three elements that constitute it (the gap, the process itself, and the plan), the authors state that the gap is contingent, and the actors of the design process have no influence on it. In our approach, the addressed design problem (the gap for Boisseau and colleagues), is open too, as it is open to the interpretation and clarification by the interested parties, as part of the design process. Although our concept of design may reach the plan (i.e. for example, the drawings of a design product), differently from these authors, we are not limiting the object of design to a (material) 'product' of industrial design. In our work, we associate to 'design' the activities that precede the code production in a digital information system design, encompassing problem discussion, deliberation and clarification, ideation of solutions, requirements elicitation, design rationale. The next section provides an overview of our proposal for the OpenDesign Platform and its boundary objects.

3 Deliberation/Rationale in the OpenDesign Platform

In this section we present an overview of the OpenDesign Platform based on the phases and activities that constitute the (SAwD) process; the boundary objects that constitute the information formalized (the artifacts); and the dynamics of activities with participants (or stakeholders) taking part in the design process. Processes of Deliberation and Rationale underlying the use of the artifacts are indicated with illustration of an specific artifact (Deliberation Frame). Technical details of the Platform development are also provided showing how it was made possible.

3.1 The Platform Overview

The Socially Aware Design model has inspired the process which we have incorporated into the OpenDesign Platform. Traditionally, this model is inspired by some Organizational Semiotics [19,29] artifacts and consists of three phases, each guided by one specific artifact. The first phase is the elicitation of stakeholders, which is made using the artifact known as Stakeholders Identification Diagram (SID) adapted from Xiaojia [33]. This artifact allows us to indicate all those who will affect or will be affected

by the product of the design, which can be categories of individuals (like developers, designers, etc.), or entities (such as universities or corporations). SID's graphical representation usually has five sequential layers that contain each other, like an onion, as we can see in Fig. 1.

The idea is that the innermost layers contain stakeholders that are more directly involved with the design product. From the center to the border, we have the Operation Layer, where stakeholders who operate the envisioned artifact are placed, followed by the Contribution Layer, where are represented the actors directly involved to the current situation or future solution; next, the Source and Market Layer represent, respectively, those who provide information and products to the discussed situations, and the related to the market; finally, the Community Layer is used to represent the broader social environment in which the problem and its solution are placed, being direct or indirectly affected by them.

During this phase of the SAwD process, participants discuss who they believe affects or is affected by the designed solution, and to which layer each stakeholder belongs. After ideas of several possible stakeholders are placed into the artifact, a deliberation can be conducted on whether or not the identified stakeholders are correctly named, categorized or even if they actually should be there. This provides a broader understanding for all participants of who are the person and entities interested or being affected by the subject, and the diagram materialises this shared and negotiated knowledge, as well as some of the rationale behind the decisions taken by the participants to materialize it in such a specific way.

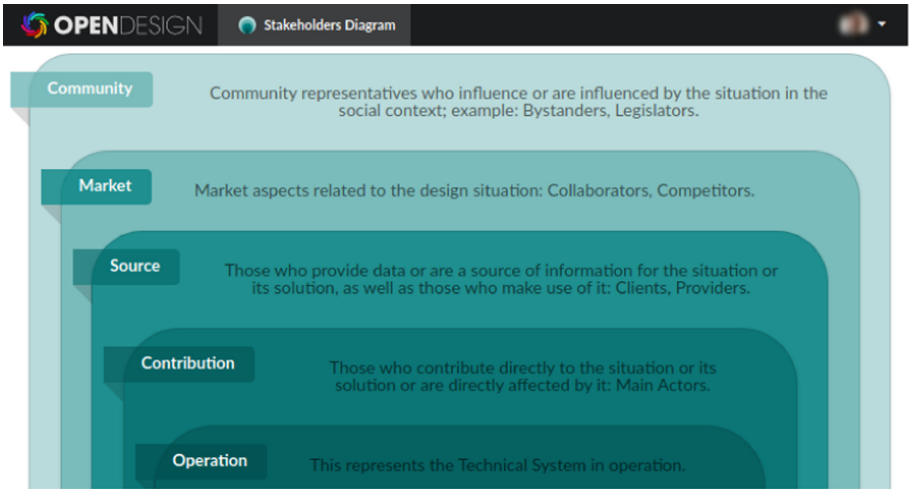

Fig. 1. Stakeholder Identification Diagram (SID) with five nested layers.

The next phase is guided by the Evaluation Frame (EF), a table-like artifact that supports the reasoning of problems and solutions associated with each stakeholder identified in the SID adapted from Baranauskas et al. [3]. Usually, it contains one column for raising issues, and another column for solutions or ideas associated with the issues. Then, each row represents one layer of the SID. Therefore, the contribution of the proposed artifact to the solution of problems of each stakeholder, and conversely, the con-

tributions of the stakeholders to the existence and operation of the artifact are clarified, from the point of view of each participant. On the OpenDesign platform, such a format was slightly adapted to allow users to navigate through the layers from a left-side menu, allowing to tag a specific stakeholder to an issue and creating links between problems and proposals as first steps towards revealing and reconstructing the elements of the rationale the participants took to make their contributions (Fig. 2).

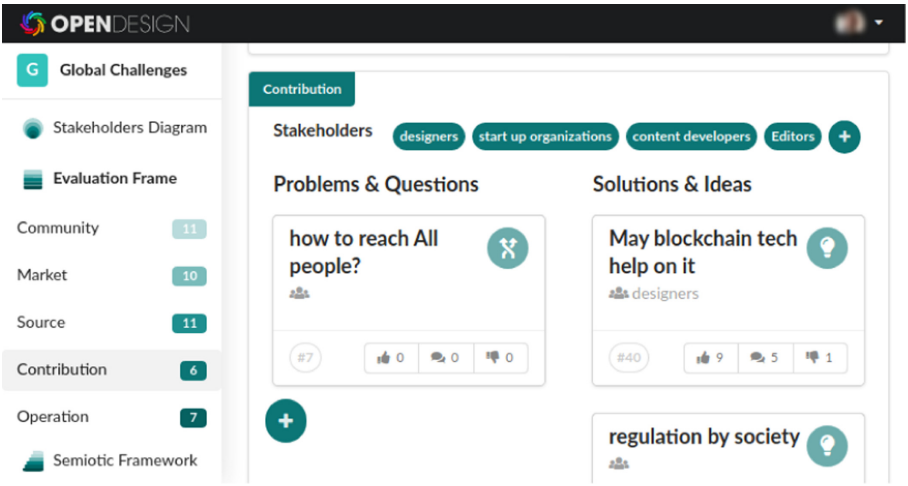

Fig. 2. Evaluation Frame (EF) with some stakeholders, a question, and some ideas in the Contribution Layer. Source: Gonçalves et al. [11].

As the number of problems and solutions grows as a multiple of the number of stakeholders, it becomes more difficult to manage a face-to-face or videoconference discussion about the participant's opinions for each issue. Therefore, in addition to the building of the EF itself, the OpenDesign Platform proposes and implements a deliberation mechanism, in which each user, interacting with the platform, provides their opinion. The deliberation aspect of this stage is reinforced by allowing users to like or dislike entries, and to add comments justifying their votes. Hence, the platform provides a **deliberation frame** (Fig. 3), where participants can raise pros and cons about a solution that was placed on the EF, or they can add neutral comments to further clarify the issue. They may also endorse each other's arguments by hitting the thumbs up of an argument, all this activity is summarized by the numbers of thumbs up/down and conversations in the card. The main idea, then, is to provide a way to document not only the deliberation process but also elements of the rationale behind decisions, either by registering participants' votes and arguments but also inviting the registering of decisions taken without enforcing a specific strategy to reach the final decision. The focus was to listen to all interested participants, avoiding speech monopoly and other face-to-face deliberation problems with the added benefit of keeping some of the trails left by the participants without increasing much the effort taken.

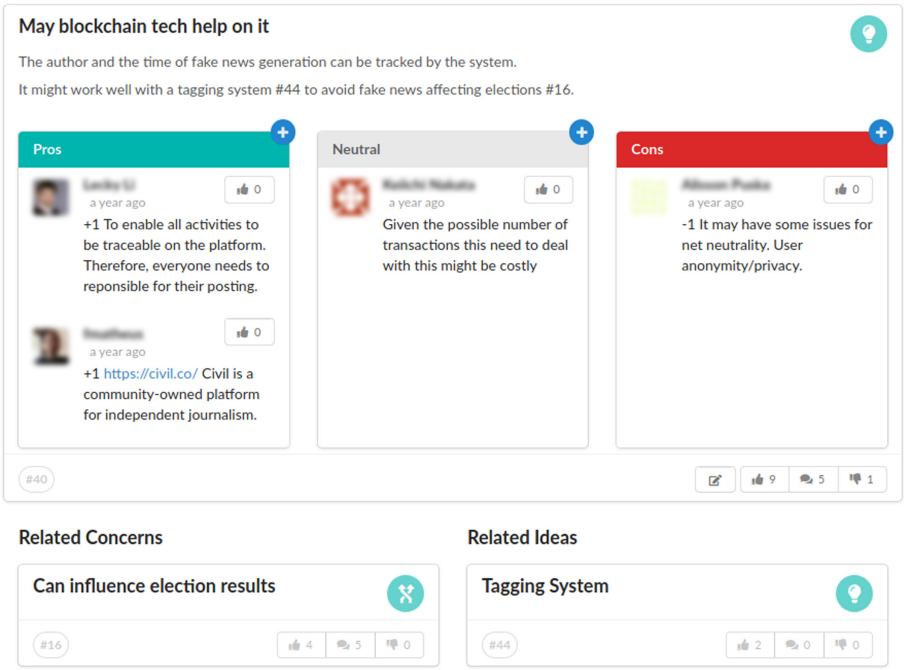

Fig. 3. Deliberation Frame (DF) with pros/cons arguments received by a proposal, followed by related concerns and alternative ideas.

Finally, the third stage is guided by the Semiotic Framework (SF) artifact adapted from Stamper [28], which provides six levels of knowledge, stacked on top of each other in a progressive manner, similar to a ladder [11]. The bottom three levels are related to the structure of signs, how they are organized and transmitted: physical, regarding their material support, density, hardware; empirics, referring to statistical properties of signals and codes, noise, medium, entropy; and syntactics, related to the combination of signs and their formal structure, regardless of their meaning. In turn, the upper three levels are related to how signs are used, in terms of meanings, intentions, and social impact they have: semantics, concerning the meanings of signs, propositions, their validity, truth; pragmatics, regarding the intentional use of signs and its practical consequences, as well as intentions, conversations and negotiation; and the toppermost social world, where consequences of the solution system in human activities are anticipated. Therefore, the SF can be a useful instrument for identifying and organizing the requirements of the design product.

Together these three artifacts provide criteria and structure to promote the process of deliberation and rationale, where participants are engaged in discussing particular aspects of the design, which they might not think of without the artifacts. Furthermore, the platform instantiates these artifacts in a way that encourages and documents deliberation and rationale. For instance, besides designers, apprentices and domain knowledge's holders taking part in a given OpenDesign session, the participants are prompted

to remember and represent the concerns and hopes of absent stakeholders. This remembering is facilitated by the SID boundary object that frames 5 distinct levels of involvement with the system, from daily operationalization to the distant community with spectators and legislators. The platform aims to give direct voice to some of these more distant stakeholders to directly participate in design and feedback about a design product, instead of being only represented.

3.2 The Platform Dynamics of Use

The OpenDesign platform can be used following certain steps. First, a challenge is proposed by one or more key participants, representing each local group of users. Not all local groups participants are necessarily operating the platform online, nevertheless they might participate in local discussions and may contribute to the solutions and proposals. Moreover, a video conference can create another communication channel, supporting all the activities, but mainly the selection of an issue from the EF to be worked out in the SF towards the design solutions. This dynamic is depicted in Fig. 4.

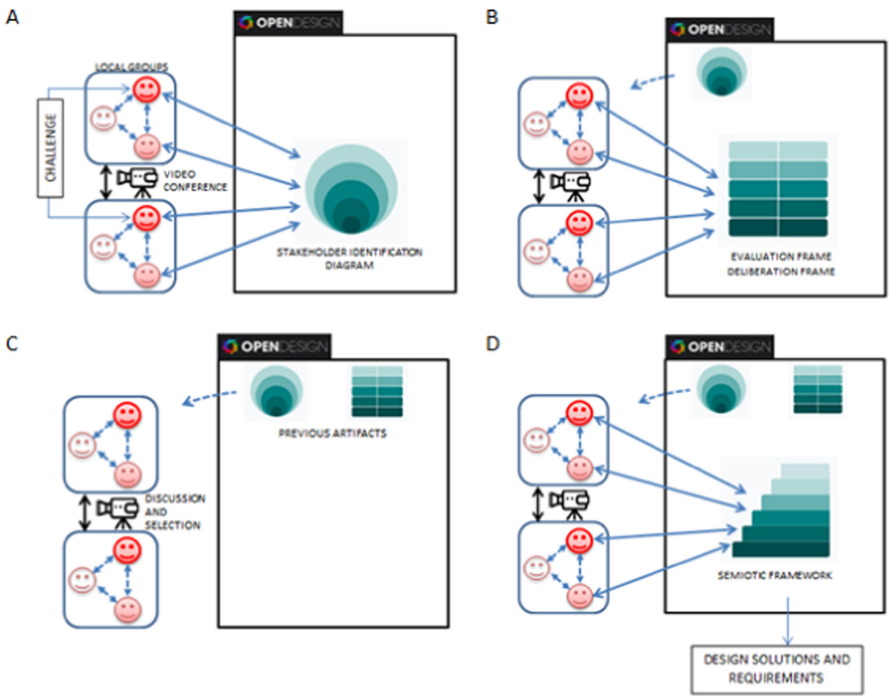

Fig. 4. Open Design Semiotic Workshop dynamics synthesized: A) a challenge is proposed by key participants in each local group and then the SID is populated with related Stakeholders; B) evaluation frame and deliberation are carried out; C) based on the rationale captured by the artifacts available at the platform, issues are discussed and a focal idea of solution is selected for the next phase; D) semiotic framework is generated, giving rise to the proposal of solutions and requirements. Source: Gonçalves et al. [11].

3.3 Platform Architecture and Technical Details

Since OpenDesign aims to support projects that need a continuous design development experimentation flow, but our main focus is on the design aspects, we choose to sum efforts with a well-established platform for online and distributed development, deployment, and operation of software products as Gitlab (gitlab.com). Since it is a loose coupling, we envisage it would be possible, in the future, to integrate OpenDesign with other platforms like Github (github.com), an alternative in the same niche. Also, even other platforms not only focused on software but in other human endeavors, e.g. Trello (trello.com), could benefit from participatory and distributed design articulated with deliberation mechanisms and rationale support provided by the OpenDesign.

Gitlab has a hybrid open source and commercial license that leverages both open contribution and financial sustainability providing software as service with enterprise premium features. Besides the source code that could allow more coupled customization, they also provide an extensive application program interface (API) allowing loose coupling with almost any functionality provided in the platform, taking advantage of the fast pace of their development; e.g. since we started this project they have even introduced a new feature with initial support for design they call "Design Management" to facilitate communication flow between designers and engineers allowing to upload design assets, e.g. wireframes, mockups, to GitLab issues. This feature will be useful for a new OpenDesign module than allows online braindraw [21,22], where distributed participants edit each other basic drawing mockups in fast-paced turns.

OpenDesign Platform has three main artifacts or boards where the unit of information is manipulated as 'cards' in its user interface, e.g. problems, proposals, and requirements. Each card is mapped into a Gitlab 'issue' and shares elements as numeric identification (id), title, description, author, creation date, and up/down votes. This allows searching, filtering, or even informing Gitlab boards layout with design labels. This integration is achieved using the Gitlab Representational State Transfer (REST) API (Fig. 5), which also allows us a more independent choice of frontend technology. OpenDesign uses the Meteor Javascript framework (1.10.2), React (16.8.6) and Semantic UI

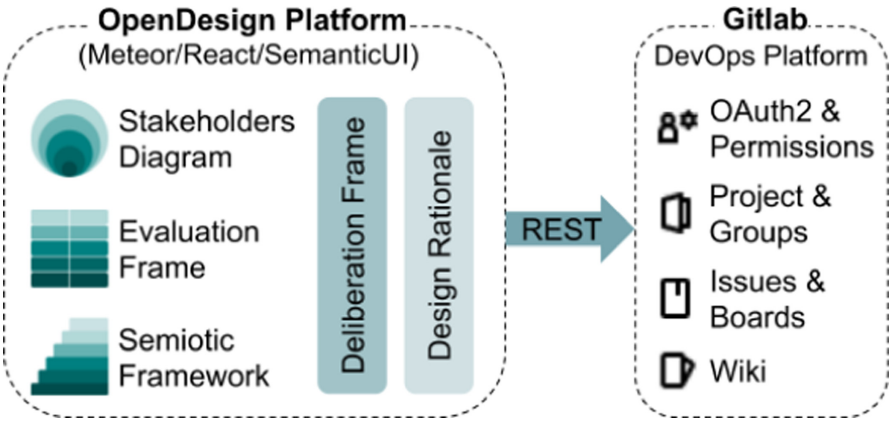

Fig. 5. OpenDesign Platform architecture and Gitlab integration.

(2.4.1) than combined provides the base for a modern-looking, fast and responsive user interface and still easy to maintain source code, once it is an academic and open source collaborative project[2]. We also take advantage of project and group organization from Gitlab, and Oauth2 authentication and access level permissions for a smooth transition between the two platforms using the same user credentials.

Other elements of OpenDesign artifacts that have no direct mapping are transformed into a Gitlab issue label to allow their usage after design, e.g. Gitlab Kanban board where cards showing the project development flow (to do, doing, done) are enriched by meaningful design labels coming from OpenDesign. Thus, each OpenDesign card becomes a design issue in Gitlab, stamped with labels of the OpenDesign artifact it comes from: 'StakeholderDiagram', 'EvaluationFrame', or 'SemioticFramework'. A Gitlab issue that comes from the OpenDesign SID or EF artifacts, receives a label stating the layer it occupies in the diagram ('Operation', 'Contribution', 'Source', 'Market', or 'Community'). Finally, in the case of an EF issue, it is also labeled with its category ('Problem' or 'Proposal') and if attributed to a Stakeholder, it also gets a label with the stakeholder title, preceded with a '@' to indicate it refers to a stakeholder. SF issues are labeled with the level it occupies in the semiotic ladder ('PhysicalWord', 'Empirics', 'Syntactics', 'Semantics', 'Pragmatics', or 'SocialWorld').

4 A Case Study on the Platform Usage

In this section we present the context and participants of our case study and introduce the representation used to analyze the participants' usage of the platform as a network of associations constituted among the participants and the artifacts they collectively constructed; then we present a qualitative synthesis of the participants' perceptions about the platform, raised through their answers to an evaluation questionnaire; a discussion of these results follows.

4.1 Context and Participants

To evaluate the proposed platform we conducted a case study in the context of a Summer School in the Organizational Semiotics Conference [25]. The case study took place as a 3h15' hands on activity, co-located in two research centers in two countries (UK and Brazil). Two conference rooms (9 and 12 participants, respectively) connected also by videoconference, and one more participant connected from home. The participants goal was to learn and practice Socially-aware Design through the OpenDesign Platform, discussing a contemporaneous problem amplified by technology pervasiveness, without corresponding human concerns - *the fake news global challenge*. Participants of diverse countries and languages, with backgrounds mostly in business and computer science, worked on the same problem, sharing ideas along the hands on activities, through the OpenDesign Platform.

Since the main aim of the case study was not to test the platform, but instead, to use it in a scenario more related to real world conditions, to drive the participants to focus on

[2] https://gitlab.ic.unicamp.br/opendesign/opendesign.

the proposed 'problem' (the fake news global challenge), the platform was previously fed in a so-called "warmup session" involving only some of the participants and other volunteers (5 co-located and 4 digitally-located, in a 1 h activity, one week before the event), providing 24 stakeholders, 13 issues and 7 proposals of solutions. The purpose of this warmup was just to seed some elements for an initial discussion, hence the SF was intentionally left out of the warmup to keep it open until further deliberation and participation of all volunteers.

The use of the collaborative platform was organized into phases: clarifying the problem, raising the main interested parties, raising issues the interested parties might have, proposing ideas of design solutions for facing the issues, discussing and selecting one potential solution to carry on, and organizing requirements for the selected solution idea. At the end, participants were invited to express their opinion on the experience with the Platform. Table 1 illustrates the Agenda of activities carried out in the 3h15' hands on meeting.

Table 1. Agenda for the hands on meeting. Source: Gonçalves et al. [11].

Boundary objects	Time spent	Activity description
Videoconference	20	Greetings; platform overview and challenge presentation
Stakeholder Identification Diagram	20	Making sense of previews entries and raising new Stakeholders
Evaluation Frame 1	35	Raising most issues and arguments
Evaluation Frame 2	30	Creating solution proposals and arguments
Semiotic Framework 1	10	Discussing and selecting ideas from the EF to SF
	30	Coffee-Break
Semiotic Framework 1	15	Discussing and selecting idea of solution from EF to SF
Semiotic Framework 2	25	Filling the SF with requirements
Videoconference	10	Wrap-up and invitation for the Evaluation Questionnaire

Table 2 synthesizes the participants' main contributions using the platform before (warmup) and during the workshop. Some participated (6) in both moments, while in the workshop some participants did not interact through the platform (4), although they exchanged ideas presentially with collocated colleagues. The deliberation (arguments) and SF filling (requirements) was performed only during the workshop.

Table 2. Participants and information they formalized into the platform. Source: Gonçalves et al. [11].

	Warmup	Workshop	Total
Participants	9	22	25 (6 in both)
Active in Platform	9	18	24 (3 in both)
Duration	1 h	2 h 45 min	3 h 45 min
Stakeholders	24	26	50
Issues	13	12	25
Solution proposal	7	13	20
Arguments	–	61	61
Requirements	–	23	23

After the hands on activity, the participants were invited to give feedback about their experience with the platform through an online questionnaire; our aim was to raise the platform's boundary objects capacity to promote deliberation, rationale and awareness, from the point of view of participants.

4.2 Data Representation for Analysis

Social networks are not just made up of persons, they consist of people who are connected by the so-called social objects [8], which we are understanding as content in boundary objects. From this perspective, Engeström [8] argues that what causes the failure of many social networking sites is the lack of shared objects acting as hubs for people's interaction [1].

In order to understand the interplay between people and non-human entities in a social scenario, the Actor-Network Theory (ANT) proposes to study social phenomena as heterogeneous networks where both human and non-human can contribute [18]. This approach allows one to acknowledge the mediation role of objects that propagate human intentions. Such heterogeneous social networks can provide a visual representation of both the participants and the artifacts they produce and interpret. For instance, scientific social networks are mediated by publications, and by analyzing both entities together we can highlight structures of scientific communities [24].

In our study, this approach is employed to illustrate the interactions between participants and the diverse artifacts (boundary objects) used in the Semiotic Workshops. Whenever a participant creates or edits a stakeholder in the Stakeholder Identification Diagram, an issue in the Evaluation Frame, or a requirement in the Semiotic Framework, a bond is established between them. Moreover, issues of the EF related to each stakeholder are also linked together. Social relations between participants arise also when a participant makes an argument on the issues created by another person. These structures allow us to evaluate the interactions afforded by the platform. For instance, the presence of cliques (short loops with a single participant) or many disconnected vertices may indicate a poor discussion, leading to less representative design proposals. Conversely, a richer discussion can emerge from associations with no single hubs, nor disconnected sub-groups.

The visual representation of these social interactions and the mediating artifacts are represented in Fig. 6 through the QUID[3] tool: participants are depicted as red circles, stakeholders from SID as blue circles, issues and solutions pointed out in EF as blue squares and Semiotic Framework items as dark blue squares. For the arguments, drawn in green, triangles mean positive, diamonds mean neutral, and crosses mean negative. When any of the elements was created during the warmup phase, it will be depicted as a dashed line linking it to the creator. Node sizes are proportional to the number of other vertices attached to it.

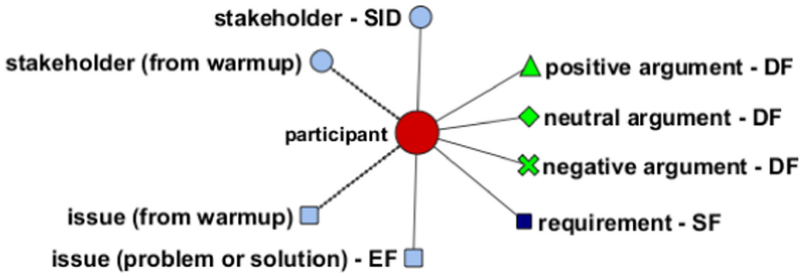

Fig. 6. Visual representation for the network of interactions between people and types of artifacts created on the platform.

Figure 7 shows an example of what can be represented using this graph notation, based on actual data from the case study to illustrate. The participant P15 pointed out the "Citizens" stakeholder in the Stakeholder Identification Diagram; afterwards, through the Evaluation Frame, attached the issue "use common sense". This user also created a positive argument to the issue. On the Semiotic Framework, user P15 added a "secured unchangeable information" requirement to the issue "may blockchain tech help on it" suggested by P17.

Fig. 7. Example of the elements used in the graph of relations.

4.3 Results

In this section we first analyze the use of the platform based on the network of associations constituted among the participants and their contributions through the artifacts; then we synthesize the perceptions of the participants about the platform, raised through their answers to the questionnaire.

[3] http://www.quid.net.br.

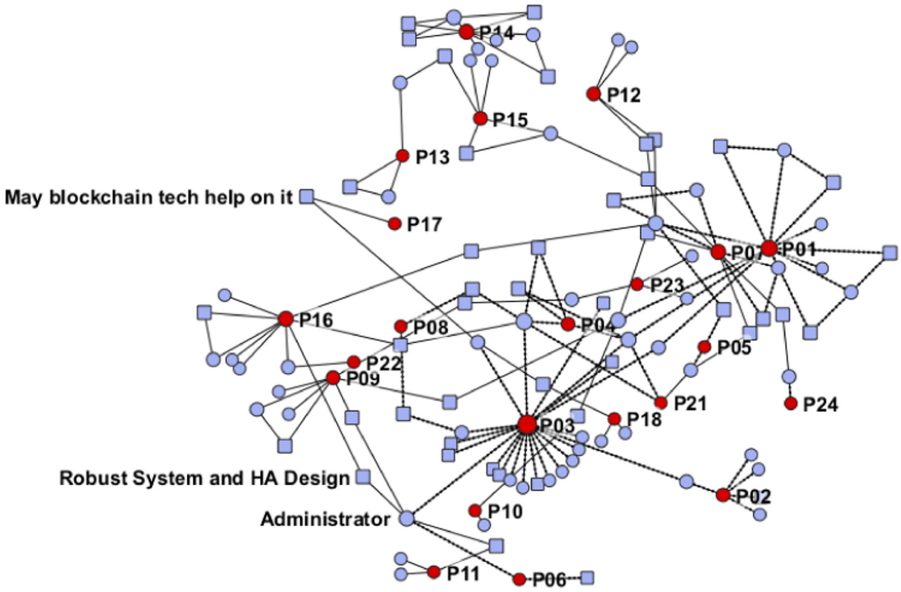

Fig. 8. Complete graph of relations between participants (red circles, randomly numbered and labeled as P*nn* to anonymize participants), stakeholders they raised or edited (blue circles) and problems and solutions pointed out (blue squares). (Color figure online)

Analyzing Interactions Through Graphs. From the interaction logs collected by the platform and processed by the Quid tool, it was possible to visually represent who contributed and, from the social objects perspective presented earlier, how their work builds up to the workshop outcomes. Figure 8 shows the main artifacts with which the participants interacted - namely the stakeholders, issues from the Evaluation Frame, and requirements from the Semiotic Frame - and the paths of interactions they create. This picture does not contain the positive, negative and neutral arguments from the deliberation phase; despite the fact that comments and issues could be created at any time in the platform, with no *a priori* order, we will depict it in a separate image.

The main feature of this graph of relations is the presence of a major connected component comprising most of the vertices, depicting the variety of interactions provided by the platform. Except for P14 and their related boundary objects, all other participants engaged in interactions with the content created by others, creating paths of associations linking most of the participants. This suggests a successful sharing of ideas and concepts among participants.

Although many contributors interacted with their own content - for instance, adding a problem to a stakeholder proposed by themselves, creating the "triangles" on the graph - they also contributed to others' contents. Also noticeable is the lack of correlation between the physical location of users during the workshops and their placement on the graph; for instance, although P03 and P16 were on different places, there is a short path between them on the graph, as they constructed collaboratively some content involving the "Administrator" stakeholder and the "Robust System and HA Design" issue.

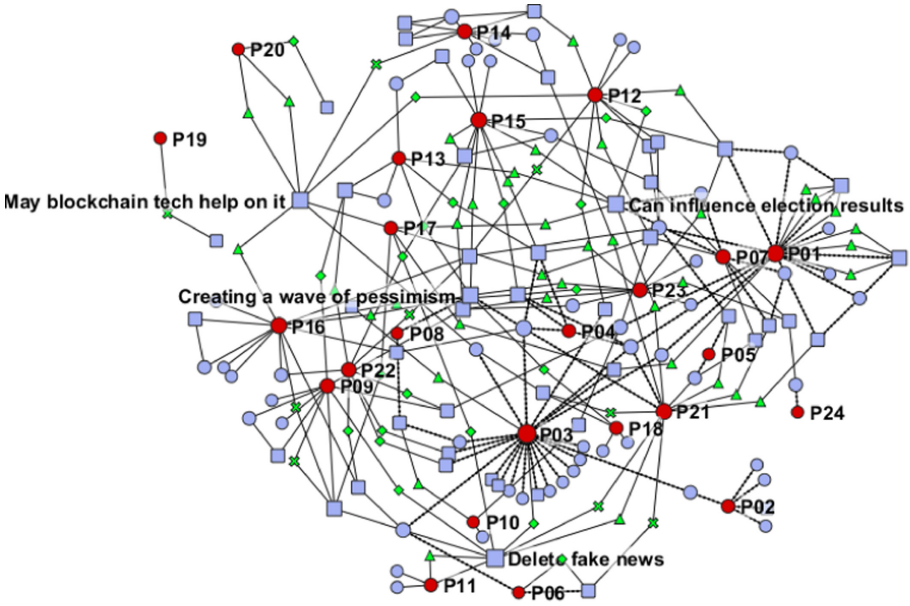

Fig. 9. Relationship between participants (red circles), problems and solutions (blue squares) and arguments (green shapes). Positive arguments are depicted as triangles, neutral ones as diamonds, and negative arguments as crosses. The issues with a greater number of associations are labeled. (Color figure online)

It is also noticeable that more eloquent participants do not necessarily attract more attention. For instance, the sole contribution of P24 was the stakeholder "social groups", which was linked by P07 to the issue "popularity of fake news". Conversely, participant P03 provided several stakeholders that did not receive further interaction by other users.

Regarding the deliberation phase, Fig. 9 brings a view on how each argument is related to the issues and solutions raised in the Evaluation Frame, and to their authors as well. As the node sizes grew proportionally to the number of other vertices now attached to them, the graph reveals the most active contributors and, according to their interaction, the most interesting subjects raised.

Issues that received most arguments are: "Delete fake news", suggested by P11, "May blockchain tech help on it", created by P17, "Can influence election results", provided by P07 during warmup phase, and "Creating a wave of pessimism", created by P08 also during the warmup. It is noticeable that most commented problems and solutions were not proposed by the most eloquent participants suggesting different profiles of participation, and showing that the tool provided a balanced discussion environment. Authors also did not try to overemphasize solely the positive aspects of their proposals. It is also noticeable that "old" and "new" issues, that is, created in different moments of the system usage, received similar attention, suggesting a successful support for asynchronous discussion and preserving its rationale.

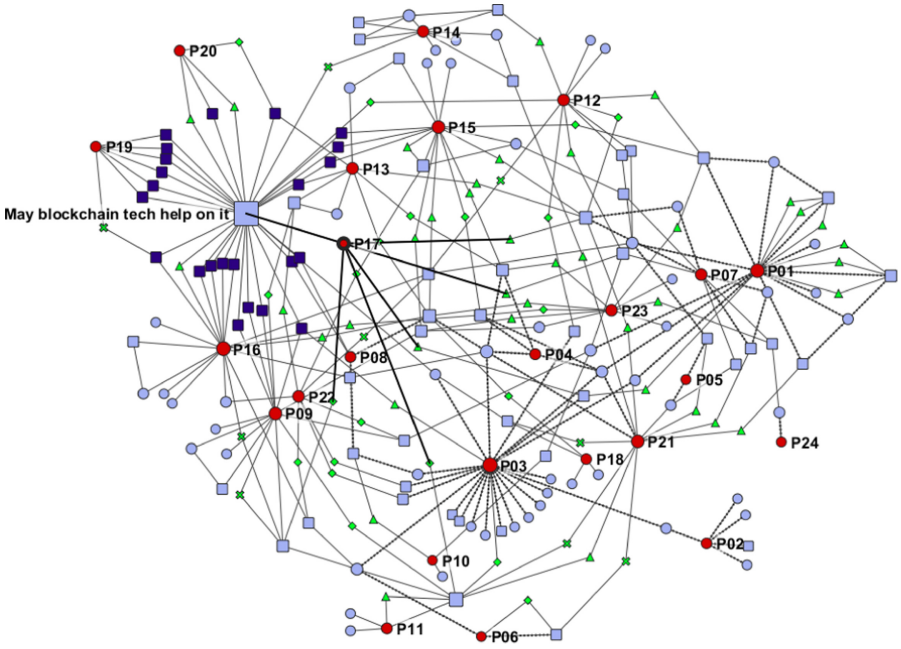

Fig. 10. Complete graph of interactions after the Semiotic Framework and Deliberation phases were carried out. Requirements of the SF are shown as dark blue squares. In bold, highlight of the interaction of the participant who contributed to the idea selected as the focal point in the SF. As the size of vertices is proportional to the number of connections, the "May blockchain tech help on it" node grew even bigger. (Color figure online)

The graph including the requirements in the Semiotic Framework (white circles) highlights the interaction of the participant P17 who contributed with the main idea ("May blockchain tech help") for the final phase. This participant registered only this proposal, after engaging in deliberation with other 5 issues and ideas proposed by 4 other participants with 3 positive and 2 neutral arguments Fig. 10. This same behavior is shared by other participants (P16, P09, P15, P13) while other participants were more engaged in deliberation (P22, P21, P23, P12) and others contributed more to SF but not in the deliberation (P19, P8).

Figure 11 brings the same content of Fig. 10, but highlighting the content created during the warmup phase in distinction to the workshop carried out afterwards. It is clear that the final solution grew over the warmup content, but most of the content was created during the workshop phase, including the final solution: in workshop phase, P17 provided the solution "May blockchain tech help on it" based on the stakeholder "designers" proposed by P03 in warmup phase. The "designers" stakeholder was also linked to a "peer review system" solution by P18, but the discussion did not go further.

Zooming in on the graph we can pick examples of distinct behavior during the activities Fig. 12. While P17 spread their contributions among several other users' contents, P01 advocated on its own side, giving positive feedback to issues he/she created

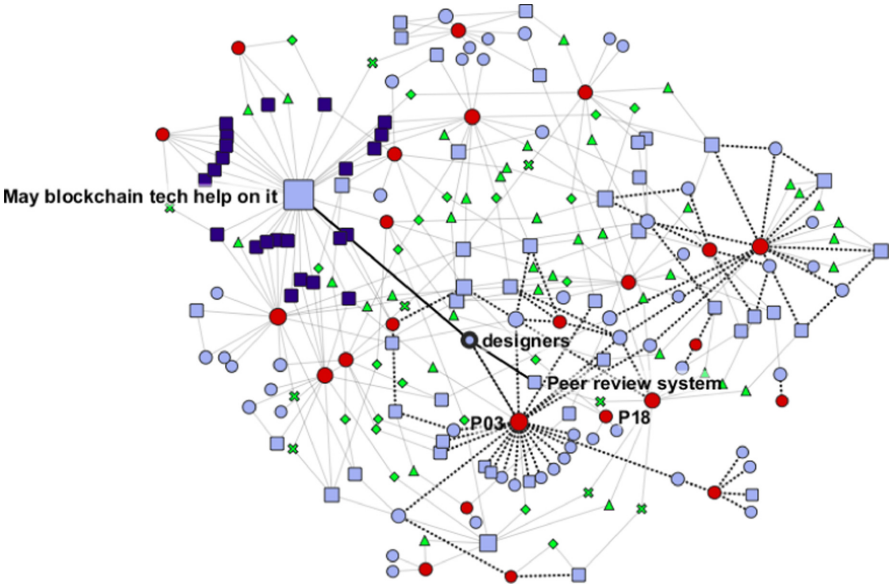

Fig. 11. Complete graph of associations, highlighting the distinction between the warmup phase (dashed edges) and the workshop phase (light gray edges). Although warmup content is concentrated on the lower right side of the graph, there are several links between it and the content created afterwards, including the final solution. (Color figure online)

Table 3. Mode of the answers for the Part 1 closed questions. Source: Gonçalves et al. [11].

Question	Mode
The format of the argumentation (Pros/Neutral/Cons) is useful for collective decision making	7
The format of the argumentation (Pros/Neutral/Cons) facilitates collective decision making	8
Voting (Like/Dislike) is useful for collective decision-making	9
Voting (Like/Dislike) facilitates collective decision-making	7
I discussed with another workshop participant regardless of the platform	9
I recorded the result of a face-to-face discussion on the platform	8
I considered arguments recorded on the platform to build my own opinion	7
I can easily relate a requirement to a stakeholder	6
A solution proposal is always related to the problem that it seeks to solve	7
It was easy to relate a requirement on the Ladder to the proposed solution that gave rise to it	8
Arguments of other participants influenced my opinion about the importance of a problem	8
Arguments of other participants influenced my opinion about the importance of a stakeholder I had not considered	9
Arguments of other participants influenced my opinion about the value of a solution	6

him/herself ("Remember to tell everyone" and "tell me more about that" - which looks more like a menta-communication). The diversity of interactions may be influencing the final choice of the group towards P17's proposal.

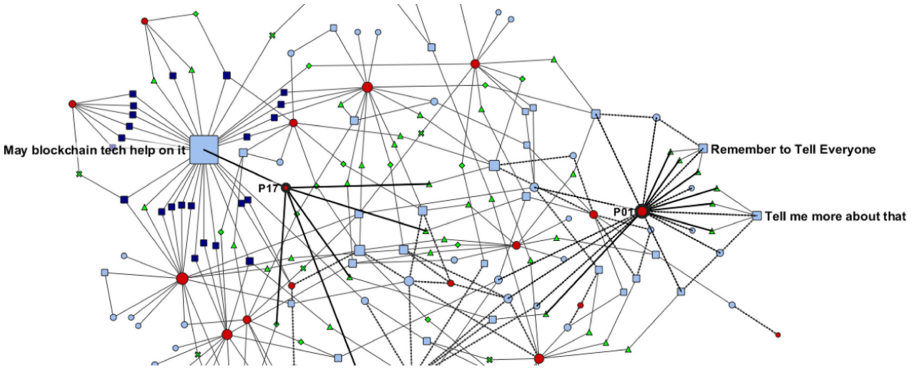

Fig. 12. Detail of the complete graph of associations, showing examples of participants with distinct behaviour profile.

Getting Feedback Through the Questionnaire. Regarding the platform usage evaluation, after the activities carried out through the platform, an invitation was made only for those in one of the two groups, not involved with the OpenDesign Project or its platform design, development or test. Eight volunteer participants answered the evaluation questionnaire. The objective of this questionnaire was to understand the ability of the platform artifacts to promote deliberation, rationale and awareness, from the point of view of activists and the hands-on course participants (platform users).

The questionnaire encompasses 28 questions organized into two different parts. Part 1 with 19 questions regarding Deliberation, Rationale, and Awareness, and Part 2 with 9 questions regarding Feelings and Usability. The questions in Part 1 used a 9 point Likert scale ranging from 'completely disagree' to 'completely agree' for 13 questions, and included 6 open questions. The questions in Part 2 used a 5 point Likert scale ranging from 'completely unhappy' to 'completely happy', using a manikin with different facial expressions for expressing the feeling. Table 3 shows the closed questions of Part 1 and the mode of answers.

For the Part 2, in the 9 questions related with feelings and usability, in a 5 points Likert scale of satisfaction with different aspects of interaction (e.g. collaboration, self presence in the solution, facility of use, feeling able to contribute, etc.), five (of eight respondents) gave the highest value (5) to them. The lowest value attributed to an item was 3 (in 5). Table 4 shows the mode of the responses for the questions in Part 2.

As for the open questions, we asked if the platform: allowed them to deliberate on the proposed ideas, made the rationale visible, and promoted the awareness of others and their ideas. Inviting them to justify their impression highlighting the platform elements that afforded or prevented each of these goals. We also asked what other mechanisms could be more appropriate, in their opinion, to achieve each of these three aspects (deliberation, rationale, and awareness). All participants agreed that the platform contributed to all these aspects for different reasons and also suggested potential improvement we present in the following section.

Table 4. Mode of the answers for the Part 2 questions. Source: Gonçalves et al. [11].

Question	Mode
Did you feel like collaborating with others?	4
Did you feel represented in the discussion?	4
Did you feel the presence of others in the discussion?	4
Did you feel you achieved something collaborative?	5
Did you feel you were able to contribute?	5
Did you feel you were free to express your ideas?	4
Was the collaboration spontaneous?	4
Would you use the system to solve another problem?	4
How easy-difficult was it to use the platform?	4

4.4 Discussion of Results

In this paper, we investigate the importance of deliberation and design rationale in the (open) design process presenting a case study conducted among participants of a Conference Summer School [25] using the OpenDesign Platform tools. Our findings point out towards the platform being able to provide mechanisms for the convergence of the design process, for knowledge management, and for supporting co-creation. Regarding the content generated through the platform and represented as associations networks, some aspects of the effectiveness of the platform tools can be highlighted:

- *Connectedness.* The connectedness of the graphs presented reflect the successful sharing of ideas and concepts regarding the problem discussed among the participants, independently of the physical location of the different working groups, their culture, and the specific professional profiles (academy, industry, practitioners, etc.) considering the participants were part of audience attending the Conference. In addition to the different physical location, different time of creation of the ideas were not barriers for the interconnectedness of the contributions, showing synchronous and asynchronous use of the platform equally useful.
- *Intersubjectiveness.* The graphs reveal the network of associations of the participants (and their contributions) who, being in different groups and despite not having previous acquaintances of each other, collaborated in the ideas of each other and reached a consensual solution. Moreover, they reached a common ground discussion independently of the prolific (eloquent) voices of some.
- *Scale.* On the scale aspect, once it is not effective or even feasible to participate in all discussions, the platform provided frames to gather organic interest of subgroups formed around an issue or idea proposal and their interconnections. To handle dialectics the platform provided a frame structure that affords capturing benefits and drawbacks of each proposed idea. By mediating discussion with a semi-structured argumentation, it was possible to collaboratively elicit which pros and cons resonate more around an idea or issue.

As for the perception of the participants for the work through the OpenDesign Platform, (raised by the open questions), the main findings regarding deliberation, rationale and awareness can be summarized as:

Deliberation Aspects

- All respondents somewhat agree that those in the same physical location have discussed regardless of the platform, but some agree their discussion was moved by the artifacts and they have recorded the results of the face-to-face discussion on the platform. The recording is necessary and hopefully sufficient to make what happened out of the platform to become a fact capable of impacting those who have not participated in that particular face-to-face discussion.
- All respondents agree that the artifacts in the platform allowed them to deliberate on the proposed ideas. They emphasized the structure of the platform as a key aspect to orient, provide sequence and overview of contributed information, keeping good flexibility and interaction among people. Besides structure, they mention aspects of flexibility of use, visibility of ideas and of thinking processes, e.g.: *"They facilitate the visualization of the ideas", "ideas and thinking stimulation"*.
- When asked how deliberation and decision-making could be improved, they pointed out that consolidation still happens to depend on video conference support and that could be improved with mechanisms such as: digital mediator, discussion turns, focus groups.

Rationale Aspects

- Most respondents agree to be easy to relate a requirement to a stakeholder, a solution proposal to the issue it seeks to solve, and to a lesser degree to link a requirement on SF to the proposed solution that gives rise to it. Regarding the artifacts, "*They contribute to build a more complete perspective of what is being discussed, in different dimensions that may not have been considered.*"
- When asked what other mechanisms could be more appropriate for making the rationale visible, they suggest "*schemas, maps, visual mind maps*", "*It will be helpful if there is a graph network that can show the relationships between different solutions*". This last aspect is something an integration of the QUID tool to the Platform could offer, visually facilitating a global view of the human and non-human actors in the solution tracking, as Figures 7 to 10 show us.

Awareness Aspects

- According to the respondents, the platform collaborates to understand the others' point of view, making visible their arguments in a non-biased way. Visibility of all ideas and their influence on the others is mentioned by the majority of respondents, e.g. "*The ideas are all shown on the platform, which are easy to check out.*" Nevertheless, they acknowledge there is still room for improvement: "*Yes, in some way because we can see productions (stakeholders, problems.) of other people and their comments. We can see how problems, ideas and other productions are related as well. But the artifacts can improve to make awareness even better*.

These results, added to the content generated through the platform during the activity, has shown the use of the platform was smooth, and the boundary objects were valuable as mediators along the process that initiated with a challenge and ended up with requirement specifications of an elected idea of solution.

5 Conclusion

The concept of open design, with roots in the free-software movement, has been recognized as a meaningful phenomenon, supported by trends in contemporary digital technology and organizations. The nature of open design presupposes the interaction of diverse people towards a co-creation of the design product (e.g. a plan, a drawing, a requirements list for the intended product or service). Moreover, these people with diverse backgrounds need to align different motivations (e.g. to influence the final result, to voluntarily contribute to the process, to get a benefit of it) to collaborate. The research community has pointed out the lack of online platform tools to support meaningful interaction and co-construction in open design, especially in the activities related to the early clarification on a design problem towards the conception of community-driven solutions.

In this work, we presented the OpenDesign platform, characterizing it by its boundary objects (artifacts), participants, and design process. OpenDesign draws on artifacts and practices of the Organisational Semiotics and Participatory Design to conduct a Socially-aware Design enhanced with online deliberation and cues to capture and reveal elements of the design rationale while participants use it. We carried out a case study with participants in two geographically distant sites attending a summer school in a Conference. They interacted through the platform artifacts to discuss a proposed design open challenge and together have evolved the conception and requirements of a design solution that emerged from collaboration.

We adopted the lens of the Actor-Network Theory to analyze the data generated from the design process through the platform artifacts. These data were processed by the QUID tool to build a graphical representation in which both the participants as well as the boundary objects are part of the same network. This visual representation allowed us to reveal the different paths the participants weave along the interaction through the platform, the tracks they leave while discussing, proposing ideas, deliberating, interacting with the others mediated by different boundary objects. Our further analysis revealed several aspects of the association between participants and the boundary objects: the connectedness of the contributions, the intersubjective relation of participants while sharing information through the platform, and the tracing back of the solution and of specific discussions along the way.

Furthermore, we presented a qualitative synthesis of the participants' feedback about the platform, raised through their answers to an evaluation questionnaire. Results reveal the participants' perception of the platform's value related to deliberation, rationale, and awareness, while they also gave valuable opinions on how to improve these aspects. Their answers also reveal very positive feedback on their feelings on the experience and usability of the platform.

We expect that this work contributes to a more systemic vision for the design of interactive systems that considers the technical solution as part of a more complex

social system and welcomes open participation. Further studies involve: a) integrating the visualization tool into the OpenDesign platform and investigating whether it can increase awareness of others' contributions; b) investigating the visual map of the network of participants and boundary objects as a mediator along the (open) design process.

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