Open Device Labs

A Global Community Movement to Democratise Testing and Evaluation on Real Devices.

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Doctoral program - Experimental Sciences and Technology

DOCTORAL THESIS

Open Device Labs – a global community movement to democratise testing and evaluation on real devices.

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TESI DOCTORAL

Open Device Labs - un moviment de comunitat global per democratitzar les proves i l'avaluació amb dispositius reals.

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The capacity to collaborate will be a decisive factor in the future perspectives of the companies.

Alfons Cornella, 2013.

Founder of Infonomia and Co-society

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Abstract

Open labs networks characterised by local activity and global connectivity have emerged to address different demands. Open Device Labs (ODLs) is a grass-roots community movement, which aims to democratise testing and evaluation on real devices, thus far unexplored academically. An ODL is a space typically equipped with mobile devices (e.g. smartphones and tablets) connected to the Internet for Web and app testing purposes. This PhD thesis investigates the ODL ecosystem to identify its main characteristics, practices, benefits, and challenges. We conducted a qualitative inductive case study through four main units. Section I explores the ODL ecosystem, both local and global, through the community core from the hosts' perspective and focuses on professional ODLs. Section II discusses the investigation of the ODL's guest users' perspective of the service. Section III explores the potential of the community to benefit the gaming industry. Section IV examines a single case of an academic ODL. Lastly, the final section presents a framework for establishing academic ODLs.

Keywords: Open Device Labs, grass-roots community movement, glocal ecosystem, online user reviews, game testing and evaluation, academic ODLs.

Resum (Catalan Version)

Han sorgit xarxes de laboratoris oberts a tothom i caracteritzats per la seva activitat local i connectivitat global per atendre diferents demandes del usuaris. Open Device Labs (ODLs) és un moviment comunitari de base que té per objectiu democratitzar les proves i l'avaluació en dispositius digitals reals, que fins ara havia estat inexplorat. Els ODLs són un espai normalment equipat amb dispositius mòbils (per exemple: telèfons intel·ligents i tauletes tàctils) connectats a Internet amb la finalitat que els usuaris puguin fer proves de d'aplicacions web, jocs, i mòbils. L'objectiu d'aquesta tesi ha estat investigar l'ecosistema dels Open Device Labs per tal de presentar-ne les seves principals característiques, pràctiques, beneficis i reptes. La recerca s'ha realitzat mitjançant una investigació qualitativa d'estudi de casos i s'ha dividit en quatre unitats centrals. La secció I va explorar l'ecosistema d'ODLs, el local i el global, a través del nucli de la comunitat des de la perspectiva dels amfitrions i centrat en els ODL professionals. La secció II va investigar la perspectiva que tenen els usuaris convidats dels ODLs sobre el servei. La secció III va explorar el potencial de la comunitat per beneficiar-se de la indústria del joc. Per últim, la secció IV presenta un marc per establir ODL acadèmics.

Paraules clau: Open Device Labs, moviment comunitari de base, ecosistema glocal, revisió d'usuaris en línia, proves i avaluació de jocs, ODL acadèmics.

Publications

The dissertation is based on the following articles:

Godinho-Paiva, Raquel (2015). Open Device Lab (ODL) - um movimento colaborativo para o uso de dispositivos reais em projetos para web e aplicativos (revisão da literatura). *Obra Digital*. Number 9. pp. 58-79. doi: 10.25029/od.2015.68.9

- Impact (2015): Emerging Source Citation Index (ESCI) – Web of Science (WOS). Open Access Journal.

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List of Abbreviations

ODL	Open Device Lab
HCI	Human-Computer Interaction
UCD	User-Centred Design
OS	Operating System
RQ	Research Question
UX	User Experience
UI	User Interface
OC	Operating Context
QA	Quality Assurance
SQA	Software Quality Assurance
SDLC	Software Development Life Cycle
SNSs	Social Networks Sites
LSCI	Localized Spaces of Collaborative Innovation
ENoLL	European Network of Living Labs
MVP	Minimum Viable Product

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Preamble

This PhD thesis submitted as a collection of published articles presents a case study research on the Open Device Lab (ODL) community movement.

Evaluation of technologies is one of the major principles in interaction design and human-computer interaction (HCI), including mobile HCI. Several studies have discussed the pros and cons of lab-based and field-based evaluations. There is no precise answer about lab versus field, but suggestions on answering *when* and *how* to go to the field (also called 'in-situ' or 'in the wild'). Field studies are conducted in 'the real world', a natural environment, and lab studies in controlled environments (Kjeldskov & Skov, 2014).

The World Wide Web was a result of a project created to solve problems of sharing information at the European Organization for Nuclear Research (CERN). It then became a phenomenon that changed the digitalisation of communication, because of its spread in the 1990s (Scolari, Aguado & Feijóo, 2012), the change in perspective of understanding the Web as a service platform, and the gradual introduction of mobile devices (Kuklinski & Pablo, 2008).

The Web's design has been supported by the World Wide Web Consortium (W3C) since 1994. The consortium has been developing protocols and guidelines to the long-term of the Open Web. W3C design principles focus on technologies to enable Web access anywhere, anytime, using any device (W3C, 2017a).

On the one hand, the market benefits from a variety of devices, brands, models, screen sizes and operational systems. On the other hand, fragmentation was identified as one of the greatest challenges faced by developers (Joorabchi, Mesbah & Kruchten, 2013). When the idea of having a space to perform tests on real devices started, in 2011, Marcotte (2010) had already coined the Responsive Web Design term, while Wroblewski (2011) wrote about the mobile first and that the Web community was facing difficulties due to hardware and software fragmentation.

This work is not interested in the lab versus field issues. The focus was the ODL ecosystem, its characteristics, practices, benefits and challenges. Here, the questions would be about simulation versus reality. Real devices, real tests, real environments

versus simulations, simulators and emulators. However, as Kjeldskov & Skov (2014) recommend, on the lab versus field, the question was about *when* and *how* not *if*. During the research, the case became more important than the issue, especially the educational branch. As lecturers in the higher education Design field, we believe it is important to give students the chance to get in touch more with 'the real world', rather than only simulation practices. Also, to show the differences between different approaches and the benefits and challenges.

Laboratories are a common facility present in educational institutions and organisations with a huge variety of purpose. In mobile HCI, labs have been widely used for evaluating technology, especially usability labs. In addition, field-based evaluation has been the focus of attention in recent years (Kjeldskov & Skov, 2014).

Real devices are a resource for all the main testing and evaluation approaches, manual and automated, in-person and remote, lab-based and field-based, user testing and expert evaluation. Despite existing evidence on the importance of testing and evaluation on real devices, there are still many technology professionals who do not make use of it.

In this context, different studies have addressed testing and evaluation both from software engineering and human-computer interaction. The market also has been offering new solutions in terms of testing on real devices.

This thesis is a contribution to the mobile testing and evaluation field, investigating a global community movement which emerged from the Web design community, to face development challenges in the real world. The thesis was written for two main audiences. Firstly, for the thesis committee, and secondly, for policymakers, practioners, community leaders and other professionals, who are interested in the main topics presented in the following sections.

The reader should bear in mind that this study has been based on the HCI approach – it is beyond the scope of this study to examine the software engineering perspective.

Thesis Overview

The first section of the thesis, the background, presents a general introduction of the research topic to present the related papers and justify the thematic unity of the thesis and the coherence of the papers presented. Following this, we present the rationale and the aims of this thesis. Next, the results are presented in five sections in which three inter-related papers are presented: two of them are published and the last one is under review. The first section presents the ODL ecosystem. The second section presents a paper on the overall satisfaction of the ODL's guest users with respect to the free service. This study was *published* in the *International Journal of interactive Mobile Technologies (iJim)*. The third section presents a paper which examined the potential of the ODLs to contribute to the gaming industry and was *published* in the *First Monday Journal*. The fourth section presents a single-case study about an ODL hosted by a public university-level institution. This manuscript is currently under review at the *Information* journal. The fifth section presents a framework for academic ODLs. Subsequently, we present a general summary of the results obtained in the thesis research, the discussion of these results, the final conclusions, and future research directions.

Background

Introduction

Defining key concepts

Here, we will briefly introduce some relevant concepts for a better understanding of the following sections. Many of the concepts presented here, are part of the literature review section of the diferrent papers published or under review.

Openness and Web Design Principles

The Open Web

CERN[1], was having difficulty sharing information when Tim Berners-Lee started working on a project to solve this problem. He realised that they could share information using the hypertext, an emerging technology at that time, and it could have a much broader application than just solving their problems at that time. Later, this project became 'the Web'. It was never an official project at CERN, but Tim was allowed to work on that. In 1990, he had written the foundation of today's Web: HTML, URL, and HTTP (World Wide Web foundation, 2008).

> *"In those days, there was different information on different computers, but you had to log on to different computers to get at it. Also, sometimes you had to learn a different program on each computer. Often it was just easier to go and ask people when they were having coffee…", Tim says.* (World Wide Web foundation, 2008)

In 1994, Tim moved to the Massachusetts Institute of Technology to found the World Wide Web Consortium (W3C). A foundation which has been developing protocols and guidelines for the long-term of the Web and is advancing the Open Web and enhancing participation in it (W3C, 2017b; World Wide Web foundation, 2008).

[1] The European Organization for Nuclear Research - (https://home.cern).

W3C design principles are: Web for all and Web on Everything (W3C, 2017b). The first is related to accessibility initiatives; and the second, to enable Web access anywhere, anytime, using any device. In their words:

- The social value of the Web; is that it enables human communication, commerce, and opportunities to share knowledge. One of W3C's primary goals; is to make these benefits available to all people, whatever their: hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability.

- The number of different kinds of devices that can access the Web, has grown immensely. Mobile phones, smart phones, personal digital assistants, interactive television systems, voice response systems, kiosks and even certain domestic appliances can all access the Web.

A survey, aiming to understand the main challenges faced by developers, identified fragmentation as one of the greatest challenges: both for the development and for the testing of mobile applications. When comparing fragmentation with unification, 76% of survey respondents agreed that the existence of multiple platforms is a challenge. Meanwhile, 23% of respondents believed that this multiplicity, is also an opportunity leading to the technological advances that drive innovation (Joorabchi et al., 2013).

Fragmentation by definition, refers to “The process or state of breaking or being broken into fragments” (Lexico, 2019b). In terms of software, fragmentation is “the inability to develop an application against a reference operating context and to achieve the intended behaviour in all operating contexts suitable for the application” (Rajapakse, 2012, p. 318).

Besides the guidelines and protocols, W3C vision involves participation, sharing knowledge, and thereby building trust on a global scale. “The Web was invented as a communications tool intended to allow anyone, anywhere to share information” (W3C, 2017b).

Open Local Labs Communities and Collaborative Global Networks

Open Labs, are initiatives of this time that emerged in different sectors like; the maker movement, Fab Labs, and real-life experimentation; Living Labs, which are classified, for example, as localised spaces of collaborative innovation (LSCI) (Capdevila, 2013). The author presented a first attempt to study the LSCI phenomenon globally. He considered three common characteristics, also related to communities of practice, shared by all LSCI:

1) They are spaces open to the general public.

2) They have a defined focus and a goal, collectively agreed by their members.

3) They share information and tools among the members, and they encourage the free sharing of knowledge.

Open labs networks have been a central theme of PhD theses. Living Labs (Leminen, 2015; Schuurman, 2015) and Fab Labs (Neves, 2014), for example; were crucial references for this thesis. Our research, is the first thesis about the Open Device Labs.

At the time that Leminen (2015) and Schuurman (2015) conducted research about Living Labs, there were numerous studies about them. For example, Leminen conducted a systematic literature review with 200 publications on the topic of Living Labs; based on the analysis of scientific and practitioner-based publications. Schuurman (2015), selected 45 papers for the literature review, based on those with more than 10 citations.

In this context, a PhD thesis about the Open Device Labs is a different challenge; not only because it is a singular and in a different community, but because at the time we began in 2015, there were no previous studies about them. A few scientific papers started to appear at the same moment.

There were other fundamental theses for the choices we made. In terms of processes, a case study PhD thesis (Ferreira, 2016), an ethnography case thesis (Takhteyev, 2000), and two other theses were referenced in terms of structure (Félez Nóbrega, 2017) and (Blasco, 2017).

Moving forward to the Open Device Labs context, in 2011; when the idea of sharing a pool of devices emerged, the Web development community was struggling with mobile hardware and software fragmentation; there were a variety of brands, models, and browsers and these were all much more unpredictable than their modern equivalents.

The user experience, was completely changed after the release of the iPhone in 2007. This event, had disrupted the prevailing view of the mobile phone user interfaces and their purpose. Before this, physical buttons, simple Web browsers, and e-mails; were the primary Internet based tools. Apple's original plan, was that some of the iPhone apps would be sourced from the Web, generally three years after the native apps were still in great demand (Charland & Leroux, 2011).

Besides these circumstances, responsive Web design was taking hold. A decade before it, John Allsopp (Allsopp, 2000) wrote about looking at the Web as a new medium with its own characteristics. In 2010, Ethan Marcotte (Marcotte, 2010, 2011) , coined the name 'Responsive Web Design' for a new approach which put together fluid grids, flexible images, and media queries[2] (Marcotte, 2014).

The Web design community, works continuously to improve their practices. The Web standards project, a grass-roots coalition; have been working on the promotion of better practices in Web development since 1998. The World Wide Web Consortium (W3C), founded by Tim Berners-Lee, have; since their inception, been developing protocols and guidelines; in order to ensure the long-term growth of an open and accessible Web for everyone (W3C, 2017b, 2017a).

In terms of testing issues, emulators[3] have been used as a common tool used for Web-based software testing. They aim is to mimic software and hardware environments, such as the various different browsers and devices. Emulators are a simple to use and

[2] A mechanism for identifying types of media and inspecting the physical characteristics of the devices and browsers that render content (Marcotte, 2014).

[3] Emulators aim to mimic software and hardware environments such as different browsers and different devices.

practical tool, but offer limited solutions; because they often lack a number of the real features of mobile devices, for example, those relating to performance.

In this context, in 2011, the idea of having shared and open spaces in which mobile devices were available, Open Device Labs (ODLs), arose. ODLs, are laboratories equipped with a variety of devices; mainly smartphones and tablets, connected to the Internet and available for free for everyone. The purpose of an ODL, is to help people in the design and development community to test their projects on real devices, see example Figure 1. In a short period of time, this grass-roots movement became a glocal networked community.

Figure 1 Open Device Lab FFM, Frankfurt, Germany.

Source: author

Glocal

The Oxford dictionary defines glocal as "characterised by both local and global considerations" (Oxford Dictionaries, 2018). According to Giulianotti & Robertson (2007), the term glocalisation derives from the Japanese word dochakuka, i.e. "global localisation", and in social theory was initially developed by Robertson (Robertson, 1992). Wellman & Hampton (1999), defined glocalisation as the combination of global connectivity and local activity. The authors, discussed the fact that Internet users became "glocalised", meaning that they were deeply involved in both local and long-distance relations: neighboring on and offline and connecting with distant friends and family, mostly online.

> *"Paradoxically, even as people are connecting globally, they are well placed to be aware of what is happening in their immediate surrounding. The coming proliferation of wireless computer networks will change this situation, but only somewhat" (J. B. Wellman, 2004, p. 19).*

Ecosystem

Ecosystem, is a term from the ecology field; which refers to a biological community of interacting organisms and their physical environment, and in general use refers to a complex network or interconnected system (Lexico, 2019a). According to Tansley (1935), the difference between the use of the term "ecosystem" instead of simply saying "system" is due to the fact that in the ecosystems, the activities are still being defined, since we do not know from the beginning where they are going to arrive.

Grass-roots

The Encyclopedia Britannica (2018), defines grassroots as "type of movement or campaign that attempts to mobilise individuals to take some action to influence an outcome, often of a political nature". Howard (2005, p. 523), writes that the:

> *"Real grassroots, the kind that grow in the ground, are a self-similar branching structure, a network of networks. Each grass seed grows a branching set of roots and then many smaller roots grow of those; the roots of each grass plant interconnect physically with the roots of adjacent plants, as any gardener who has tried to uproot a lawn has learned. There is a grassroots element to the Net that was not until very recently, involved with all the high-tech, top-secret doings that led to ARPANET - the BBSers".*

Enthusiasts with their own benefits, who were involved in the BBS[4] project, grew explosively without external resources and raised the simplest and cheapest structure for CMC[5].

According to Smith et al. (2017), networks of community groups have been innovating grass-roots solutions for social demands for decades. Grass-roots innovation movements identify issues and questions neglected by different areas like technology, and arise in unconventional settings through unusual combinations of people, ideas and tools. In his analysis of six case studies from different places and times, from 1976 to 2017 are: hackerspaces, fablabs and makerspaces. A final important aspect pointed out by Smith et al. (2017, p. 9), linked to the maker movement, is that:

> *"there is always innovative activity at grassroots level operating beneath the radar of economic and scientific institutions. Those institutions conventionally set research and development agendas, and provide support and resources, and market and capitalize upon innovation society. However, innovative grassroots activity attains movement characteristics only when motivated by an explicit normative desire for social change committed to values of social justice and environmental sustainability" .*

And the maker movement is a very good example of a grassroots activity attaining the status of a movement, as they make free devices and objetcs and offer them for the democratic use of everybody.

Community

"Communities are clearly networks" (B. Wellman & Hampton, 1999). Community is a group of persons who share social interactions; social ties; and a common interactive format, location or 'space' in netnography. 'Space' is the 'cyberspace' of computer

[4] Computer Bulletin Board System - like real grass-roots, BBSs grow from the ground up, are self-propagating, and are difficult to eradicate (Howard, 2000).

[5] Computer-mediated communication.

science or technologically mediated communication; the limits of common belonging can be understood in terms of self-identification as a member; repeated contact; reciprocal familiarity; shared knowledge of some rituals and customs; and some sense of obligation and participation (Kozinets, 2010). Community, is the sense of belonging to a group with shared interests and values (Rosen, 2007).

In the development context, Garcia & Steinmueller (2003) argues that if open source has a sustained advantage as a process innovation; the source should be how the developer community is recruited, maintained and organised or self-organised. A useful starting point to consider the operation of an open source community, is the hiring of individuals to undertake in the development of open source software.

Openness

Himanen (2001), made an analysis in his book 'The Hacker Ethic and Spirit of the Information Age', based on the hackers-enthusiastic programmers' values. The first hacker's ethos, was that activity should be motivated primarily by a desire to create something valuable for a community rather than by money. A community which shares their work with others in a spirit of openness and cooperation, and writes: 'openness is resilience'. Openness, was a key of the Internet, the Web, and the Open Source Software, for example.

From a business perspective, Ahonen (2015) argues that open systems encourages diversity and companies of the future to be far more open:

> *"An example of the language of openness: open innovation, open legal frameworks, open data, open APIs, open business models, open organisation, open source, open ecosystems, mutuality as a business strategy. To get to a comprehensive understanding of these capabilities companies will need to evolve their ability to practice appreciative inquiry".*

Collaboration

Over the last few years, collaboration has been a good word, but it has not always been synonymous with a positive concept. In the past, it was related to spying for example, or "colluding with competitors in restraint of trade and monopolizing

industries to plotting against others" (Rosen, 2007, p. 15). The author, writes about the culture of collaboration from a multiple industry perspective; such as automotive, healthcare and aerospace. He argues that the phenomenon of the culture of collaboration, was pervading organisations of all kinds and proposed a framework for making teams and organisations collaboration-friendly. According to him, there were ten cultural elements that were typically present when a collaboration works:

- Trust – a basic principle to exchange ideas and create something with others. Ideas often get better with collaborative inputs. Concerns about having an idea stolen, is common in competitive organisational cultures.
- Sharing – not everybody likes to share. Hoarding information prevents the free flow of ideas. Sharing information, improves collective creation and makes people more valuable.
- Goals – common objectives and goals lead to collaboration, while different goals create conflict and confusion.
- Innovation – the desire to innovate fuels collaboration and it enhances innovation. The best collaboration produces new approaches.
- Environment – the design of both physical spaces and virtual environments, impacts innovation and collaboration.
- Collaborative chaos – it means the unstructured exchange of ideas creates value. Effective collaboration requires some degree of chaos.
- Constructive confrontation – the idea is to confront concepts rather than people, in order to take advantage of exchanging viewpoints.
- Communication – inextricably linked with collaboration, including inter-personal and organisational forms of communication.
- Community – sharing interests and goals creates a sense of community. Without community, people often lack comfort and trust.
- Value – to create value is the primary reason to collaborate.

These elements are part of Rosen's idea culture collaboration, "without a Culture of Collaboration, the best processes, systems, tools, and leadership strategies fall flat" (Rosen, 2007, p. XII).

Non-profit organisation

Non-profit organisations, are organisations that are not intended to make a profit. Simon & Donovan (2001), outlined a typical path of development for the average non-profit organisations; in which some move deftly through the following life stages and others get stuck in one stage for a significant period of time:

- Stage One – **Image and Inspire**: This is the vision or idea stage, where the organisation is not yet formalised and where imagination and inspiration is abound. This stage is characterised by lots of enthusiasm, energy, and creativity, but at this point; the organisation really is merely a dream for a better world that is inspirational and worth striving for.
  Primary question: Can this dream be realised?
- Stage Two – **Found and Frame**: This is the start-up phase of the organisation, when it receives its official non-profit status and all of the activities of founding and framing an organisation occurs. Like stage one, this stage is characterised by excitement and high levels of interest by many people; accompanied by the fear that formalising the dream will result in the loss of its magic. The act of incorporation, formally establishes the organisation.
  Primary question: How are we going to pull this off?
- Stage Three – **Ground and Grow:** At this stage, the organisation is concerned with building its foundation by grounding its activities and growing the "business". Organisations in this stage are focused on establishing systems of accountability, however; the need for growth on multiple fronts may be overwhelming to those running the organisation. The Ground and Grow stage, has a mundane feeling of "taking care of business"; but it also has numerous enticing intersections, choices, and challenges.
  Primary question: How can we build this organisation to be viable?
- Stage Four – **Produce and Sustain:** This is the mature phase of the organisation's life, when production is at its peak and sustaining the organisation is a high priority. The organisation is very stable, yet that same stability may make it stale, as there are concerns for the procedure, slow creativity and growth. Stage Four is a productive place that, at its peak; feels a

little like an automatic pilot. Staff are doing their work effectively and enthusiastically.

Primary question: How can the momentum be sustained?

- Stage Five – **Review and Renew:** At this stage, the organisation is reinventing itself in some way, shape, or form; through a process of review and renewal.

  Primary question: What do we need to redesign?

Decline and Dissolution: Sometimes, an organisation is forced or chooses to shut its doors. In this model, decline and dissolution is not considered an inevitable stage of an organisation's life cycle, but rather one of the routes that an organisation can find itself taking. An organisation can face dissolution at any stage.

At this point, we have presented some of the most important concepts used in this thesis. Others, will be found in the published papers or under review. We close the background section and move onto the following sections: literature review, rationale and thesis aims; with the results being presented in five units, the general discussion, and conclusions.

Literature Review: Open Device Labs

The majority of the results presented here was published in Godinho-Paiva, Raquel (2015). Open Device Lab (ODL) - um movimento colaborativo para o uso de dispositivos reais em projetos para web e aplicativos (revisão da literatura). *Obra Digital*. Number 9. pp. 58-79. doi: 10.25029/od.2015.68.9

Introduction

1. Literature review procedure

The literature review was performed during the period of April and May 2015. Using Open Device Labs (ODLs) as a focus, the selection of data resources available from available publications were collected from: a) electronic databases – Mendeley, Scopus, Web of Science, CAPES journal portal (Brazil), Academia, Bielefeld Academic Search Engine (Base), and Safari Books and, online using the search mechanisms - refSeek, iSeek, Jurn, HighBeam research, Google Scholar and Google.

The selection was carried out through the usage of the keywords: “Open Device Lab” AND “ODL” and “Open Device Lab” OR “ODL”,

The results were separated into primary sources, the writings of the community, secondary sources and books that make comments about the community (Eco, 2007).

Due to the recent emergence of ODLs in the industry context, there is limited literature related to this topic. For this reason, we included primary sources in the review: the labs’ official pages, the community directory, blogs, newsletters, discussion groups and published interviews with the main people involved in the growth of the organisation and current movement maintenance. These have contributed to gathering initial data about the organisation history and development, project proposal and main actors. The secondary sources revealed evidence about the need of adding real devices in the software development life cycle (SDLC). Even where we did not find studies regarding the ODLs in the results obtained, they appeared in the secondary sources as an alternative in the testing phase with real devices, usually accompanied with brief information about their definition and goals.

The keyword “ODL” appeared in most of the informational resources with repetition of the results already obtained and presenting new results about studies from seven other definitions for the abbreviation and, for this reason, we are able to say that when we mention ODL, we are not talking about: Oracle Diagnostics Logging (ODL), Object Description Language (ODL), Object definition language (ODL), Open and distance learning (ODL), Optical Delay Lines (ODL), Outcome Differential Level (ODL) or On-demand learning (ODL). We are only discussing about Open Device Lab (ODL).

2. Results

In the secondary sources, the authors refer to Open Device Labs as places for conducting tests with real devices, either as a main option or as an alternative. Irrespective of divergences among implementation approaches, such as responsive websites and dedicated websites[6], which is not our focus, the authors mentioned the importance of performing tests on real devices. The subject matter is usually approached in the sections or chapters regarding tests issues. In addition, many authors recommended ODLs especially for those who do not wish or are unable to invest in their own laboratories.

In Grigsby and Gardner (2011) we found the first registers regarding the process of creating a community for sharing mobile devices for tests. The authors' suggestions for testing on mobile devices were:

"1. Start with valid code in a desktop browser;[...]

2. Use mobile emulators and simulators;[...]

3. Invest in a small number of devices – buying a few phones is unavoidable;[...]

4. Beg, borrow, and steal – connect with others doing mobile development and share devices. Consider creating a central wiki of devices in your community so that people can easily find and share devices. Better yet, go big and build a community device testing lab like the one we're building in Portland;

5. Visit your local mobile testing centre – nearly every city has a mobile device testing centre. You may refer to them by their more common name: carrier stores. [...]

6. Remote device testing services – sometimes you really need to test a specific Scenario;[...]

7. Prioritize your testing – […] based on the decisions you made early in the project about the devices your customers are most likely to use".

[6] Websites designed for specific devices.

Grigsby & Gardner (2011) recommendations are similar to the other authors proposals presented in the following paragraphs. There is a more practical and faster phase for verifying the first possible problems, where it is important to use simulators and emulators, because they solve another range of problems. However, in order to really get to know the responses of an ongoing project, one must use the real devices that are most used by the targeted market. Grigsby and Lyza's book was a key source for documenting the beginning of ODLs history, grounds, and themes, including peer-to-peer device sharing, the creation of a community device testing lab, and the Portland initiative.

Peter-Paul Koch[7] in the chapter related to mobiles recommended to, "start mobile browsing testing today" and create a device lab or find an Open Device Lab. He described ODLs as a place where besides being able to test on real devices, it provided an opportunity to acquire useful contacts to discuss technical issues and the mobile market, and maybe gain clients (Smashing Magazine, 2012).

There were four sources which deal with responsive design, (Fielding, 2014; Jehl, 2015; Marcotte, 2014; Peterson, 2014). Ethan Marcotte was responsible for naming the term responsive design for building projects that are adaptable to different devices. In chapter 5, Becoming Responsive, when dealing with iterative collaborative design, he introduced ODLs as an alternative for tests on real devices for those who choose not to invest in their own collection. In this context, the author considered planning, design, development and delivery as common projects phases, which that could be carried out, by the team, in an individual or combined way. The phases could be performed in a sequence, with each team performing their parcels separately, or combined in a hybrid way for further design and development.

Jehl (2015) proposed the need to think about responsive design in a responsible way. This was a result of his experiences in places like Cambodia and other areas in the world in which he faced many problems in using the Internet. Thus he is aware from a personal perspective the unknown sectors of device fragmentation, which allowed him

[7] Mobile platform strategist, Web developer, browser researcher, consultant, and trainer in Amsterdam, the Netherlands http://www.quirksmode.org/.

to increase his collection for testing. The tests issues were approached in chapter two, Sustainable Detection, within the item Testing Responsibly, in which he argued that in order to guarantee the website functioning, tests on real devices were necessary. He also suggested the pursuit of an Open Device Lab, as an alternative for those who were not able to invest a considerable amount in devices. If this was not possible, performing them on emulators was an alternative, although it presented disadvantages, such as the browser was executed on a different hardware, the updates were slow, the connection speed was usually slower, and feedback of the interaction with the real device was not obtained.

Fielding (2014), in the chapter 'Testing a Responsive Site', proposed more focus on the process effectiveness, and explained how to test a responsive website on a Web browser and in a device. Shown below in a succinct way, are the phases developed by the author:

1. Load the responsive website URL in your browser,

2. Resize the window,

3. Use emulators,

4. Use simulators,

5. Use physical devices, as an alternative look for an ODL,

6. Use remote access online solutions, in the case of not having access to devices or laboratories.

Peterson (2014), in chapter 8, 'Mobile and Beyond', emphasised two main issues to reflect on about projects: devices and users. In her opinion, the key to the responsive design success was to test the website on various devices. The test phases suggested were the same as those approached previously in this paper.

The authors presented above addressed common themes related to mobile design and testing such as responsive design, testing phases, the importance of using real devices, and ODLs as an economic alternative for testing. User-centred projects intend to correspond to user expectations, but it is not easy to deal with hardware and software fragmentation in the mobile technology market.

Knott (2015) addressed similar issues regarding the user with a different proposal. He dealt with tests and the mobile telephony market with more emphasis on the importance of acknowledging the consuming market and its expectations for tests and projects development. In his opinion, when there is an experienced proposal related to the environment, besides testing the mobile applications on devices, it is also important to test it in the real environment.

For example, if an app was tested for snowboarders and skiers that accesses slope information, one that was able to record the speed of the current downhill run and make it possible for users to share records directly with their friends, there was the need to test these functions on a slope (Knott, 2015).

In chapter 3, Challenges in Mobile Testing, based on a survey regarding the targeted public and considering fragmentation problems, the author suggested a different strategy, performing tests in groups per device type:

1: High priority: A - New devices with powerful hardware and big screens with high resolution and pixel density. Devices belonging to this group might be wholly compatible to their app in terms of functionality, design and usability.

2. Medium priority: B – Medium hardware with smaller CPU, screen resolution, and smaller size than the devices in group A. The project does not need to be perfect for this group, due to its smaller screens.

3. Low priority: C - small CPU and low screen resolution and density. It is still important to support the app fully in terms of functionality, the design and usability. However, this may differ from the other groups because the hardware may be too slow to provide enough response capability.

With the groups defined and turning to the tests, the same proposal as the previous authors was presented: having an in-house laboratory, invest in some devices, rent some mobile devices or seek for an ODL.

Satrom (2014) also brought up new themes related to development and tests on devices. He addressed various issues related to performance and render, and their importance for different browsers:

A: File size matters

B: Always test on devices

This means the file sizes for mobile devices should have more attention because they affect the rendering time, which requires more information to be downloaded and it consumes more data allowance and battery. Using approximated test methods, such as testing the same browser they would use in the cellular telephone on the desktop is not the same thing. There are results that can only be obtained if testing is done on a real device and that is why it is important to use a test laboratory. Once again, ODLs are pointed out as an alternative for performing tests, although there was no description about their purpose or any link about this factor.

Ultimately, Castro and Hyslop (2014) addressed development issues on Web development, tests, depuration and publication. In chapter 20, 'Testing & Debugging Webpages', after presenting the testing phases already mentioned, they suggested the usage of ODLs as a free way of testing Web pages.

One may note that even the authors who have different goals regarding technology follow similar recommendations about the methods. It is normal to question the need for tests with real devices, as there are emulators and simulators that solve some of the problems and remote tests that operate real devices from long distances. Software solution appears to be more accessible because, even if they are paid services, they do not require a continuous investment on a device collection. However, they do not offer results that are only obtained with tests on real devices like user research, user experience evaluation and usability issues such as the interaction with buttons, with touch and connection performance.

We note that tests are a common theme in the literature presented. In general, different project methodologies have foreseen interface and interaction tests in different phases of the lifecycle. Because of the devices launch cycle and new resources, it is fundamental to monitor the mobile device and software market in order to perform function tests and carry out potential updates (Knott, 2015). Moreover, because of hardware and software fragmentation, it is necessary to select the market targeted in the project to be developed and verify which browsers are

more used, so they can be supported (Fielding, 2014). It is also necessary to select the devices to be tested because it is impossible to test on all models (Grigsby & Gardner, 2011; Khalid et al., 2014; Sillars, 2015).

According to Peterson (2014), some of ODLs were company laboratories open to the community; others were hosted by private companies, co-workings or non-profits. Some of them work in a totally free way and others charge a small fee as collaboration for ODL maintenance (Casanova et al. 2013). According to Knott (2015), some laboratories lend devices to the community out of the ODL space as a library.

Later, after we published the literature review, we set up database alerts, which helped us to keep up to date with new publications related to the ODLs. Since then, there has been new publication referring to ODLs, for example in the American Software Testing Qualification for the Mobile Tester the labs are listed as one of the most common approaches to test on a large range of devices (ASTQB, 2015). In addition, ODLs were mentioned in books addressing performance measurement (Firtman, 2016), moving to a responsive Web design and building stage (Inayaili de León, 2016), code quality testing and device labs (Scott, 2017), and mobile testing (Black, 2018). Moreover, other academic studies related to ODLs have been published. Hicks (2015) covered a rationale for setting up a lab and related issues, possible configurations and integrations with other services like library maker spaces. Horgan (2019) provided information about an ODL hosted by a university level institution. A common problem addressed in these latest works and also on online blog posts relate to the lab set up challenges.

At this point, the need to perform tests on real devices might be obvious, although there are many people still not using real devices to perform tests. In 2015, a survey showed that 29% of 504 respondents, technology professionals, were only using software solutions to test mobile platforms (SauceLabs, 2015), see Figure 2. In 2017, a survey on Twitter showed that only six percent of 926 participants had a large device

lab, see Figure 3, and the last State of Testing Survey Report showed that just over half of 1,700 respondents[8] reported testing on mobile devices (Smartbear, 2018).

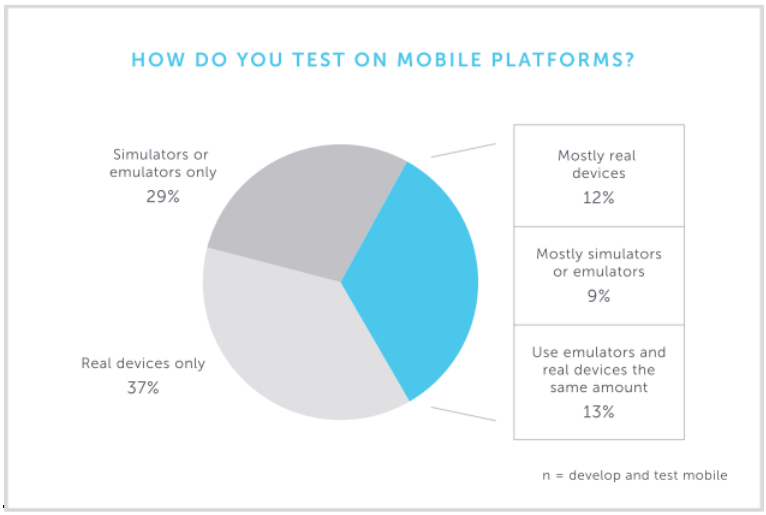

Figure 2 A graph of mobile testing based on a survey of 504 technology professionals responsible for the quality of Web and mobile applications

Source: SauceLabs (2015)

Figure 3 Smashing Magazine survey on Twitter

Source: Smashing Magazine (2017).

3. Conclusions

The literature review provided evidence about testing and evaluation methodologies emphasising the importance of real devices. The review also allowed us to identify the lack of studies regarding the movement, a recent phenomena not yet explored as a

[8] Manual Testers, Automation Engineers, Developers, Consultants, QA Managers and Analysts from more than 16 different industries globally.

potential revealing case. In the succinct way in which they were presented in the literature, one may infer that the function of ODLs are popular knowledge, but this is not the case.

We have identified that there are particularities belonging to groups or certain ODLs that are derived from the type (resident, mobile or virtual), the culture (country where it is located) or the organisational structure to which it is linked (company, university, co-working, non-profit).

4. Summary of gaps in the literature

- The literature review identified testing and evaluation on real devices as a requirement for mobile development, but not yet a mainstream practice.
- The review also identified a lack of evidence about Open Device Labs characteristics, practices, benefits and challenges both in local communities and in the global movement.
- Furthermore, the differences between labs hosted by private companies and educational institutions remains sparse due to the literature not referring to their differences.
- Ultimately, we identified there are straightforward ODLs and others who have struggled with opening and in keeping open long-term, but there was no information about these ODLs.

Rationale and Thesis Aim

Rationale and thesis aim

The focus of qualitative studies is a broad central question with associated sub questions. The inquirers state research questions (RQs), not objectives or hypotheses. The RQs serve to help to focus the study and to guide how to conduct it, and it "may address a description of the case and the themes that emerge from studying it" (Creswell, 2014, p. 139). So, for this study we had as the central question:

- How does the Open Device Lab community work?

To answer the central question we worked on the following specific research questions addressed in five interrelated sections, which comprises three scientific papers published or under review in peer-review journals:

1. What characterises the Open Device Lab community's ecosystem? (Section I)
2. What can be learned about the ODL ecosystem from online user reviews? (Paper I)
3. How do the Open Device Labs support game testing and evaluation? (Paper II)
4. How does an ODL hosted by an educational institution work? (Paper III)

Following Creswell arguments, the study's objectives are answering the research questions. On the other hand, defining objectives for this research helped to choose the approach. So, we worked on:

- To explore how the Open Device Lab community works;

1. To describe and explain the Open Device Lab community's ecosystem
2. To explore the ODL ecosystem from the user guest perspective
3. To explore how the community support videogames
4. To explore how an ODL hosted by an educational institution works

Ultimately, as a final result of the data analyses, this thesis aimed to propose a framework for academic ODLs.

In the following paragraphs, we present the general methodology choices to address this thesis aims. Later, the reader will find specificities about the methods, sample and population, data collection and analysis used in each paper presented.

This thesis follows the fundamentals of a research approach put forward to John Creswell (2014).

1. *paradigmatic approach* – interpretive (Tracy, 2013)
2. *research approach* - qualitative study
3. *research design* - case study (Stake, 1995; Yin, 2014).
4. research methods:

    4.1 Data collection - documents, interviews, direct observation, participant observation, and fieldwork notes.

    4.2 Data analysis - general inductive approach (Thomas, 2006)

    4.3 Data interpretation – meaning derived from comparison of the findings with information gleaned from the literature and researchers' personal view couched in their professional experience.

In the interpretive paradigm, also termed the *constructivist* or the *constructionist* paradigm, both reality and knowledge are constructed and reproduced through communication, interaction, and practice. An interpretive worldview analyses social action from the actors' standpoints gaining empathic insight into others' viewpoints, beliefs, and attitudes. This is a paradigm in which "knowledge about reality is therefore always mediated through the researcher" (Tracy, 2013, p. 40).

Qualitative studies aim to explore and understand social and human problems ascribed by individuals or groups based on "emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data" (Creswell, 2014, p. 4).

Case study is an approach developed to study human social life by sociologists working at the University of Chicago from the 1920s to the 1950s (Atkison, Paul and Hammersley, 2007). It "is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Stake, 1995). A particularity of Case Study research is the use of different sources for gathering evidence, six sources according to (Yin, 2014) concisting of documents, archival records, interviews, direct observation, participant-observation, and physical artefacts.

Ethnography and netnography were taken into consideration for conducting this research. Although, we chose case study as the proper approach for the research rationale, questions and the nature of the community and sources available.

We chose case study as research design because according to Yin (2014) it is a method more indicated when the main research question looks for the *how* or the *why*; a research where there is little or no control over the behavioural elements and where the focus is a contemporary social phenomenon. It is a type of research in which the researcher develops an in-depth analysis of a case. In addition, for this PhD thesis the case itself is of primary interest in the exploration, in other words the case is dominant. This is what Stake (1995) called an *intrinsic case* when compared to *instrumental* cases, used to understand something else where the issue is dominant. According to Yin (2014) case studies comprise different audiences:

- Due to the large number of theses and dissertations in the social science that rely on case studies.
- Help others to understand a phenomenon
- A case study report can itself be a significant communication device

In Figure 4, we present the case study research process based on Yin (2017).

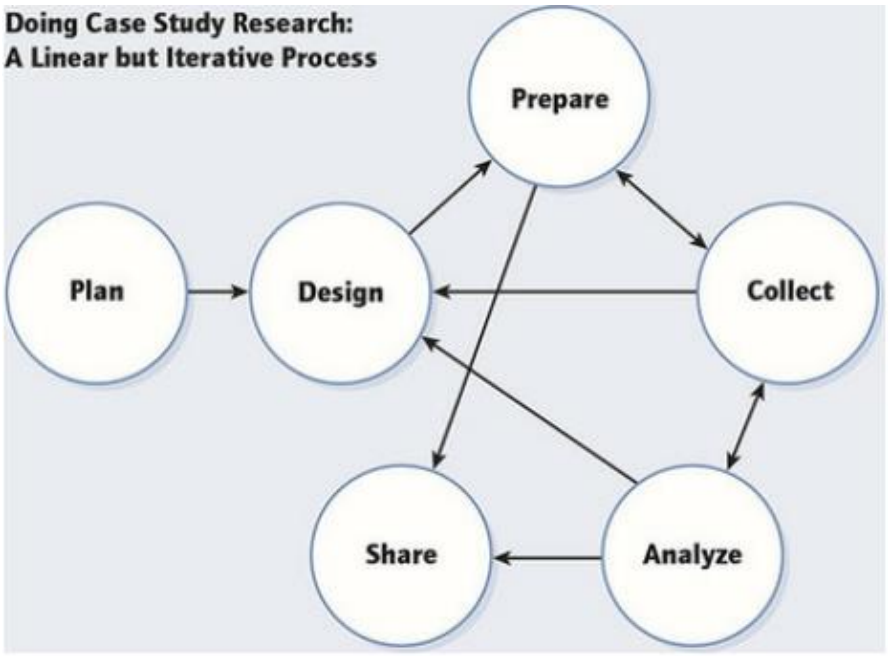

Figure 4 Case study research process

Source: Yin (2017, p. 1)

In case study research, five components of research design are especially important: a case study's questions; its propositions, if any; its case(s); the logic linking the data to the propositions; and the criteria for interpreting the findings (Yin, 2017, p. 27).

For the data analysis, we chose a general inductive approach (Thomas, 2006, p. 237) because its purposes are to:

a. condense raw textual data into a brief, summary format;

b. establish clear links between the evaluation or research objectives and the summary findings derived from the rawdata; and

c. develop a framework of the underlying structure of experiences or processes that are evident in the raw data".

Sources and data collection

The data collection was conducted from April 2015 to April 2019, based on documents, interviews, direct observation, participant observation and fieldwork notes.

Documents – most of the data were information from websites, Figure 5. A part of it was from books and papers used in the literature review, and a few data were documents collected when we visited some ODLs to conduct the interviews.

Interviews – We conducted a mix of prolonged and shorter case study interviews (Yin, 2014) depending on the participant availability. In total, we conducted 29 interviews with 37 participants from Germany, the Netherlands, Finland, Sweden, Ireland, the United States, and the United Kingdom.

We interviewed six key actors involved at the beginning of the movement, Andre Jay Meissner, Jeremy Keith, Jason Grigsby, Lyza Gardner, Anselm Hannemann, and Christian Schaefer. In addition, we interviewed 20 ODL managers corresponding to 14 Open Device Labs (12 professional and 2 academic labs), three students and the other eight participants were technology professionals working with software development.

The first interviews were conducted in Germany, due to the fact it was the country with the highest number of ODLs at that time. The ODLs managers were recommended by the community manager according to active presence and

availability. The other countries were selected to verify possible geographic differences in the sample as well as to comprise the largest ODLs in number of devices.

Direct-observation – this was conducted at the labs where we carried out the interviews, at the conferences where the principal investigator volunteered: Beyond Tellerrand 2016 and SmashingConf BCN 2017; and at the PhD traineeship at the Institute of Technology Tralee 2018.

Participant-observation – we have been trying to set up an ODL at the University of Vic, Spain, since 2016, see details in the appendices. In additon to this, we also collected data as participant-observers at Beyond Tellerrand 2016 and SmashingConf BCN 2017; and at the PhD traineeship at the Institute of Technology Tralee 2018.

Fieldwork notes – we used these to document and reflect on the observation of the data collection.

Data analysis

The data analysis was conducted manually and using computer assisted qualitative data analysis (CAQDAS), based on the general inductive approach for qualitative studies mentioned previously (Thomas, 2006).

This case study is not concerned with statistical generalisability, it is field oriented and uses a homogeneous sample, which means that the sample population shares a set of common characteristics (Crossman, 2018).

The online documents represent all the labs registered in the online directory; approximately 157 labs. During the four years we were collecting data about the ODLs, some labs opened and others closed.

Figure 5 Example of an ODL profile on the community website used to collect data.

Source: Opendevicelab.com (2018)

Data analysis strategies

Qualitative analysis often use a general procedure and in an ideal situation blend it to specific research strategy steps (Creswell, 2014). Therefore, for the data analysis we used the general inductive approach (Thomas, 2006), coding the categories inductively (ground up) and using mainly descriptive and *in-vivo* methods (Saldaña, 2009).

In the following Table 1, we present the Thomas (2006) table comparing four qualitative analysis approaches to locate the general inductive approach in relations to other commonly used qualitative analysis strategies: grounded theory, discourse analysis, and phenomenology.

Table 1 A comparison of qualitative analysis approaches

Comparison of Qualitative Analysis Approaches

	General Inductive Approach	Grounded Theory	Discourse Analysis	Phenomenology
Analytic strategies and questions	What are the core meanings evident in the text, relevant to evaluation or research objectives?	To generate or discover theory using open and axial coding and theoretical sampling	Concerned with talk and texts as social practices and their rhetorical or argumentative organization	Seeks to uncover the meaning that lives within experience and to convey felt understanding in words
Outcome of analysis	Themes or categories most relevant to research objectives identified	A theory that includes themes or categories	Multiple meanings of language and text identified and described	A description of lived experiences
Presentation of findings	Description of most important themes	Description of theory that includes core themes	Descriptive account of multiple meanings in text	A coherent story or narrative about the experience

Source: (Thomas, 2006, p. 241 Table 1)

> *"The general inductive approach is most similar to grounded theory but does not explicitly separate the coding process into open coding and axial coding. As well, researchers using the general inductive approach typically limit their theory building to the presentation and description of the most important categories"* (Thomas, 2006, p. 241).

In Table 2, we present the Thomas (2006) table based on Creswell 2002 p. 266 used to conduct the process of inductive coding.

Table 2 The coding process in inductive analysis

The Coding Process in Inductive Analysis

Initial reading of text data	Identify specific text segments related to objectives	Label the segments of text to create categories	Reduce overlap and redundancy among the categories	Create a model incorporating most important categories
→	→	→	→	
Many pages of text	Many segments of text	30 to 40 categories	15 to 20 categories	3 to 8 categories

Source: Adapted from Creswell (2002, p. 266, Figure 9.4) by permission of Pearson Education, Inc. (© 2002, Upper Saddle River, NJ).

Source: (Thomas, 2006)

In terms of interpretation, it is important to remember that we looked for information about the community ecosystem, practices, and education connections. The principal investigator resume is available at the end of the document (appendices). It is important to understand our research orientation and coding decisions (Saldaña, 2009).

The codebook was developed using a standard iterative process (MacQueen et al., 1998), see an example in appendices. We assigned to each code four "elements": 1. definition; 2. When to use; 3. When not to use; and 4. An example, which aims to present a "representative" quote from the data.

Quality assurance - data verification

For the internal validity of the thesis, we employed the follow strategies:

- Triangulation of data - the convergence of data collected from different sources to determine the coherence of a discovery (Yin, 2014). Therefore, we conducted a

triangulation analysis based on the data obtained from multiple sources, including the document analysis, the interviews, and the observations (Creswell, 2014).

- Respondent validation - systematic feedback of the informant as a way to rule out the possibility of misinterpretation, although the participant's feedback is not more intrinsically valid than his answers in the interview (Maxwell & Wooffitt, 2005). Since the beginning of the research, the main informant of the community participated in the verification of the published information.

To conclude, we conducted research using the qualitative approach. The philosophical assumption was interpretive. The research design was based on case study research in which our data analysis followed the general inductive approach, where the main mode of analysis was focused on the narrative and the metaphor we found in our data.

An overview of each section is presented below:

- Section I – Describes and explains the Open Device Lab (ODL) ecosystem in terms of the local and global main characteristics, practices, benefits, and challenges. The sample was progressively collected from April 2015 to April 2019. This section focuses on professional ODLs from the hosts' perspective and introduces a general view of the community before exploring specific themes discussed in the papers presented in the following sections.
- Section II – Presents a paper published in the *International Journal of interactive Mobile Technologies (iJim)*. This study focused on the ODLs' guest user perspective based on a sample of n = 217 online user reviews. The sample was collected between 7 and 9 May 2017 and was updated until 8 January 2018.
- Section III – Presents a paper published in the *First Monday Journal*. This study explored the ODLs' potential to support the gaming industry though a case based on three main sources: online documents, observations, and data from interviews. The sample was progressively collected until September 2017 and considered the 151 labs registered at that moment.
- Section IV – Presents a paper *under review* at *Information Journal.* This study explored how an ODL hosted by an educational institution works. The sample was collected in two main phases: the first phase was online and

began in March 2015, and the second phase was in-person during a two-month period from April to May 2018.

- Section V – Presents a framework to help in the setting up and the maintenance of academic ODLs on the basis of the data gathered about what worked and what did not for different ODLs in different countries.

I. Open Device Labs – A Grass-roots Community Movement

The movement history and evolution of Open Device Labs

As mentioned in the literature review, we identified in Grigsby and Gardner (2011)'s study what we consider the first register of initiatives to create a community to share devices for testing, "Better yet, go big and build a community device testing lab like the one we're building in Portland" (Grigsby & Gardner, 2011).

This idea of community device labs had been considered for some time in Mobile Portland meetings in the USA, before the ODL community emerged. A non-profit organisation, it was founded by Jason Grigsby[9], dedicated to educate, promote and support the mobile technology community in the city and surrounding areas (J Grigsby, personal communication, June 29th, 2015). They would get together once a month for presentations, discussions and networking from the beginning of 2008 until March of 2015, when the last meeting was held (Portland Mobile, 2015). The laboratory was more an action of the organisation for helping local developers and bringing visibility to the city as a destination in mobile technology. Jason commented about the idea of setting up a community device lab at some tech events, at one of which Jeremy Keith[10] became aware of what was being developed. In May 2011, at the Mobilism Conference Mobile Browser panel[11], featuring representatives from Nokia, Opera and RIM and moderated by Jeremy Keith, browser fragmentation, remote device testing, and emulators were discussed. Lyza Gardner[12] attended this panel and from the happenings in this conference, the creation of the first ODL resulted.

[9] Cloud Four co-founder, a mobile Web development company, Co-author with Lyza Gardner of the book *Head First Mobile Web* (2011).

[10] Irish Web developer, who is internationally recognized as a conferencier, founded the design agency Clearleft in Brighton, England in 2005. He guides the company's technical direction and acts as the Research and Development wing of Clearleft investigating. Author of the blog adactio.com, and of the books *DOM Scripting* (2005), *Bulletproof Ajax* (2007) and *HTML5 for Web Designers* (2010) (Clearleft, 2015)

[11] https://vimeo.com/24220367

[12] Lyza is a developer and co-founder of Cloud Four.

Following this event, on April 30th, 2012, Jeremy Keith wrote on his website[13] about the importance of performing tests on real devices and how he had been acquiring mobile devices for his collection and he invited his readers to show up and get to know the laboratory he had assembled in his company, Clearleft, Brighton, UK:

> "In the meantime I've been setting up a desk at the Clearleft office for these devices so that they can stay charged up and within reach. We've always had an open-door policy here, so if you want to pop around, use our WiFi, and test on our devices, you're more than welcome. Give me some advance warning on Twitter and I can put the kettle on for a cup of tea. [...] Think of it as a quick'n'dirty, much smaller-scale version of Mobile Portland Device Lab" (Keith, 2012b).

Jeremy's differential for opening the first laboratory to the community consisted in not worrying about bureaucratic issues and sharing Clearleft space through the Internet. From this moment on, developers started to offer their devices, on Twitter and in person, in order to increase the collection. The positive and collaborative reaction from the people interested caused a series of actions in the movement organisation. Josh Emerson, Clearleft's front-end developer by that time, created a page on Clearleft's website with the list[14] of available devices constantly updated, and containing the brand, the model, the system and the donator. Jeremy kept writing about these actions, stimulating Brighton residents to use the space and suggesting that residents of other locations search for partnerships in their areas and start other sharing communities (Keith, 2012c). A few weeks later, in May 2012, Jeremy Keith and Remy Sharp[15] presented the laboratories idea at the Mobilism Conference in Amsterdam, and within a few months laboratories in England, Sweden, the Netherlands and Germany opened (Salminen, 2012). With more people interested in

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[13] adactio.com

[14] http://clearleft.com/testlab/

[15] The founder of Left Logic company, co-author of the book *Introducing HTML5*, author of blog remysharp.com and speaker at tech conferences.

the laboratories and with their constant advertisements on the Internet, several laboratories started to appear in Europe; in London created by Shaun Dunne at the Mozilla space, in Exeter in the United Kingdom, and in Malmo in southern Sweden (Keith, 2012a).

From July 2012, when Andre Jay Meissner[16] decided to dedicate part of his time to organise the movement and increase it with the help of several collaborators, the community has started to increase its global visibility. At that time, there were only eight ODLs (first phase), all of them in Europe, which had been united in a list published on his website, klick-ass.com, which slowly started to be updated with the opening of new laboratories until the movement created its own website (Meissner, 2012).

In September of 2012, Viljami Salminen, designer and founder of Helsinki Device Lab, Finland, published the text "Establishing an Open Device Lab" in Smashing Magazine, which became one of the most important actions that really spread the ODL idea around the world. Following that, Andre Jay Meissner created the NPO (non-for-profit organisation) 'LabUp!' to help non-profit ODLs to get off the ground and to continue to support them. The 'LabUp!' was organised with the collaboration of Anselm Hannemann[17], Christian Schaefer[18], Timm Jansen[19], Viljami Salminen and Bruce Bowman's.[20] A Labup.org website was set up to help people interested in opening their own ODL based on the following goals:

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[16] Mainly responsible for ODL movement – an entrepreneur, former CEO, speaker, with expert knowledge in SaaS, commercial Web, ecommerce and a broad range of experience in IT services.

[17] Opendevicelab.com front-end developer - Writes on the topic of social media support and continuous supporter of 'LabUp!' since October 2012.

[18] Opendevicelab.com back-end and additional front-end developer - social media supporter and collaborator of 'LabUp!' from October 2012 to January 2014

[19] Developer, computer scientist, provided support for the movement.

[20] Product Manager of Adobe Shadow, later Adobe Edge Inspect, used by some ODLs.

- Provide useful information about how to get your lab off the ground by direct communication and frequent newsletters
- Provide a directory of ODLs so they are easy to find: http://OpenDeviceLab.com
- Provide a central point of contact to device manufacturers and encourage and facilitate the donation of needed devices to your labs
- Help to create and provide useful Software for ODLs
- Future plan 1: build a simple marketplace for individuals to donate hardware to be used on a first-come first-serve basis by all participating ODLs. (Help wanted! Please contact us if you can support setting that up!)
- Future plan 2: raise a fund for people to donate money to help ODLs buy devices from manufacturers that are not sponsoring the idea of ODLs. (Help wanted! Please contact us if you can support raising funds!)
- Help in communicating your lab to the world - DONE: List of Open Device Labs around the world (LabUp!, 2015).

The establishment of 'LabUp!' was one of the most important actions for increasing the movement. Before that, there was basically only information about local actions. The 'LabUp!' helped them to unit interests, make contacts with device manufacturers and software companies, organise administrative meetings and invest in public relations, media, brand, website and support for the movement, speaking at conferences, writing papers and arranging events (Meissner, personal communication, June 1st, 2015).

During the same period, the laboratory in Portland resumed its actions in order to complete the bureaucratic, physical space, device, and use forms and development issues to then open the doors to the community in October of 2012 (Grigsby, 2012).

In January 2013, Andre Jay Meissner, Christian Schaefer and Anselm Hannemann published the ODL directory: OpenDeviceLab.com, Figure 10. This website became the main means to advertise the movement with updates regarding scope numbers, laboratories' location map and contact information. They also started to use Twitter, @ODL and @LabUpOrg, which later became one of the main channels of media advertising for the newly opened ODLs, their assessments and events related to the

movement. In the same month, Mannheim ODL also published the Open Device Lab app, an Android version with functionalities similar to the website (Meissner, personal communication, June 1st, 2015).

On October 26, 2013, for the first time nine ODLs and 'LabUp!' managers met in Nuremberg, Germany, for an in-person meeting. Until then they would communicate through a specific group on Google Groups, through low frequency reports at 'LabUp!' or directly through Twitter, for example. The in-person meeting aimed at exchanging knowledge on managing and maintaining an ODL, presenting the best judicial practices, public relations and marketing, as well as discussing how the Open Device Lab ideas of communication and common goals could be advanced with joint efforts. Some of these practices, such as the judicial ones, would apply more to Germany and Europe, however, the meeting generated a post with several suggestions for all the existing registered ODLs (Meissner, 2013b).

In November of the same year, 'LabUp!' organised the first dedicated Open Device Lab for publicising the movement, specifically for the event 'Beyond Tellerrand'[21], an annual event of Web design and development that takes place in Germany. They had assembled an ODL with borrowed devices, where they performed several tests on projects in order to show the importance of using the devices. The action has had a wide scope and generated a post on Meissner's website, explaining how to assemble an ODL for specific events (Meissner, 2013a).

In January 2014, they incorporated DYDD[22] (Donate Your Dusty Device), as an opendevicelab.com page. The new page was implemented as a global media launch with the goal of encouraging donations of devices as well as to publicise the ODL labs.

[21] Event where the principal investigator volunteer in 2016 as part of the participant-observation data collection for this thesis.

[22] http://opendevicelab.com/DYDD

The results of the different actions performed by 'LabUp!' for promoting the movement resulted in a nomination for Game Changer 2014[23].

Currently, the community is still maintained by André Jay Meissner, who has been investing his efforts in helping the movement. In order to do so, he has become the administrator and main accountable person for the organisation and the maintenance of the movement. In addition, he is in charge of the texts, newsletters to the members, social media, press, contacts with the industry, reviewing information to be published, financial investments of things, which have not been donated and, finally, providing individual support for people interested in opening an ODL or those who have any problems with their ODL.

The movement in April 2019 completed seven years since the first laboratory opened its doors to the external community. Progressively, it finished the year of 2012 with more than 30 ODLs registered. By the end of 2013, there were more than 90, by December of 2014 there were more than 130, by the end of 2015, 2016 and 2017 there were more than 150, in June 2018, there were 150, and in April 2019, there were 152 labs. The highest number was in 2016 with 157 labs registered – see Figure 6. This total was distributed across 35 countries. Most of them are located in Europe and North America, Figure 7.

[23] This category celebrates something that really helped the industry and the community move forward. It could be a new Web design tool, a GitHub project, an outstanding article that kicked off an important discussion, and so on (The net awards, 2015).

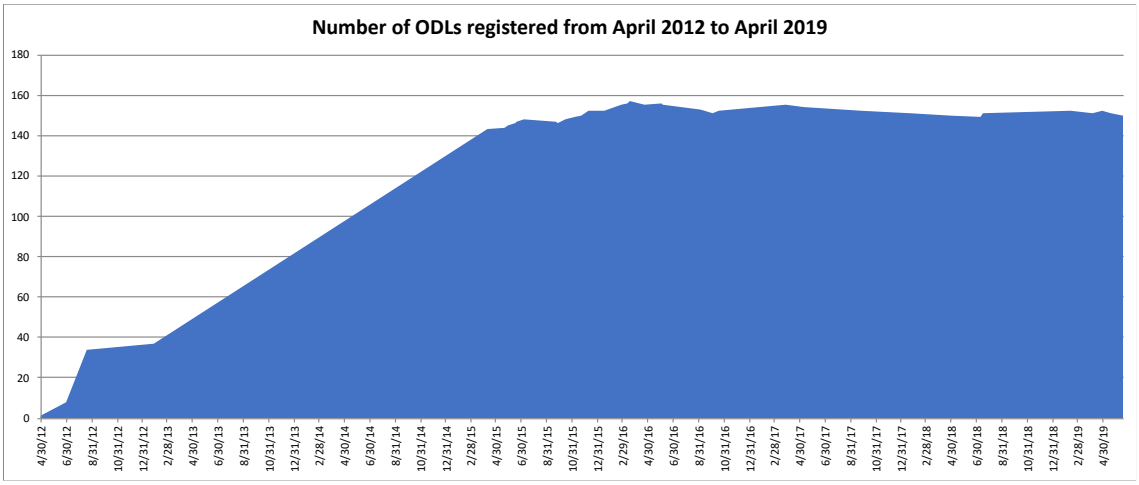

Figure 6 Number of ODLs registered on the community website over a seven year period.

Source: author

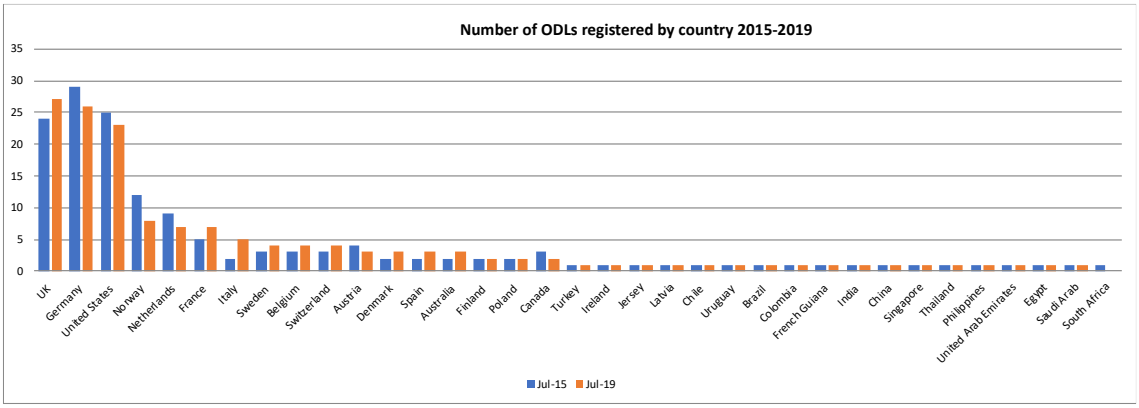

Figure 7 A comparison between the number of laboratories per country in April 2015 and April 2019

Source: author

We finish this section with a summary of the evolution phases of the ODL, see Figure 8. During these years, there have been some changes in terms of the sustainability of the labs. The first ODLs were established with device donations, first from local developers and then from mobile phone manufacturers. The next ODLs were device labs organised to become open device labs, primarily or completely funded by the host. The most recent issue are the labs which do not follow the shared device labs model and look for a sustainable model, because both device and software licence donations have been uncommon in recent years.

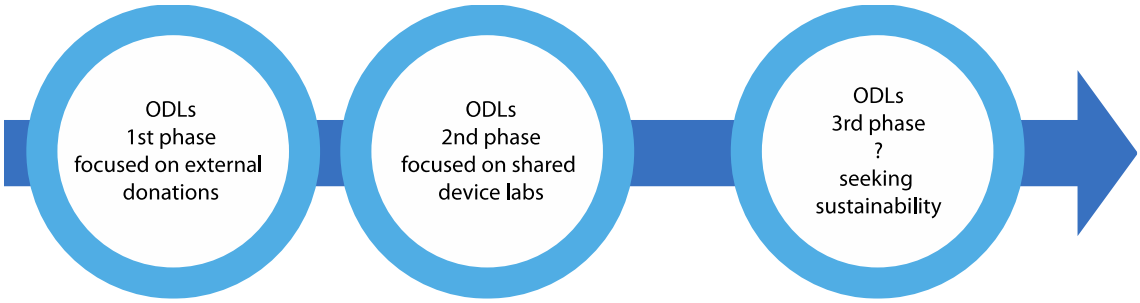

Figure 8 The phases of ODL's evolution

Source: author

ODL's glocal ecosystem

They define themselves as 'a grass roots community movement. They establish shared community pools of Internet connected devices for testing purposes of Web and app developers. In result, ODLs lead to an ultimate improvement of the Web & app experience both for developers and for consumers' (ODL, 2018).

The ODL ecosystem is characterised by local activity and global connectivity, Figure 9. The global action occurs in the online space, while the local connectivity is in the offline space. ODLs have common characteristics but multiple different implementations. In this case, the global challenges are on the online and remote running of the community and actions to help its members. And the local challenges are in the offline and in-person running of a variety of implementations in different communities across the globe, related to the setting up, maintenance of labs and guest help.

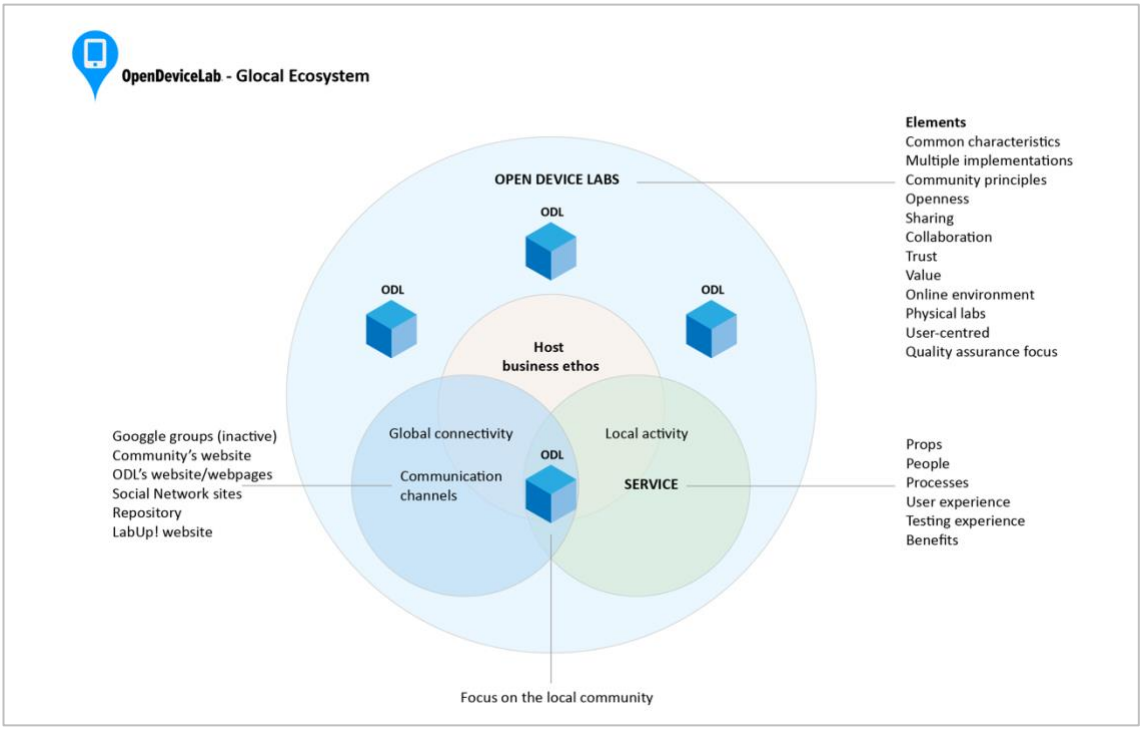

Figure 9 ODL's glocal ecosystem

Source: author

The Global

The common elements which characterise the ODL's glocal ecosystem are: common characteristics and multiple implementations, community principles (openness, sharing, collaboration, and trust), value, online Environment, physical labs, user-centred and quality assurance focus.

Community management

Online presence and global connectivity – as explained before, the global actions occur online. The community set up a Google Group (currently inactive), a website with a directory of ODLs, a Twitter, a repository – GitHub, and the LabUp! website. These are the main channels to keep informed about the movement, both for hosts and guests.

The Google Groups

This was an important channel for the global community. It was created in 2012, and active until 2014. The online group was a place to 'share what is working and what isn't working. So the people building labs in different communities across the globe can seek assistance from other people tackling similar problems' (Grigsby, 2012).

The website – opendevicelab.com

The OpenDeviceLab.com, Figure 10, is a directory of ODLs which put together most of the information on it and has three main goals:

– Help people to locate the right ODL for the job;

– Explain and promote the ODL movement; and,

– Attract contributors and sponsors to help and donate to ODLs.

Most of the laboratories are in physical spaces, but a few are mobile and can be shared between locations or set up for specific events. Thus, they can be of three types:

– Resident: when the ODL is hosted by a company or institution, permanently, at a specific address;

– Mobile: when the ODL does not have a permanent location, it moves around to events, co-working spaces, coffee shops and other spaces; or

– Virtual: in general, when they are organised in a specific location, e.g. for a Meetup, conference or other event, and usually for a short duration (ODL, 2018).

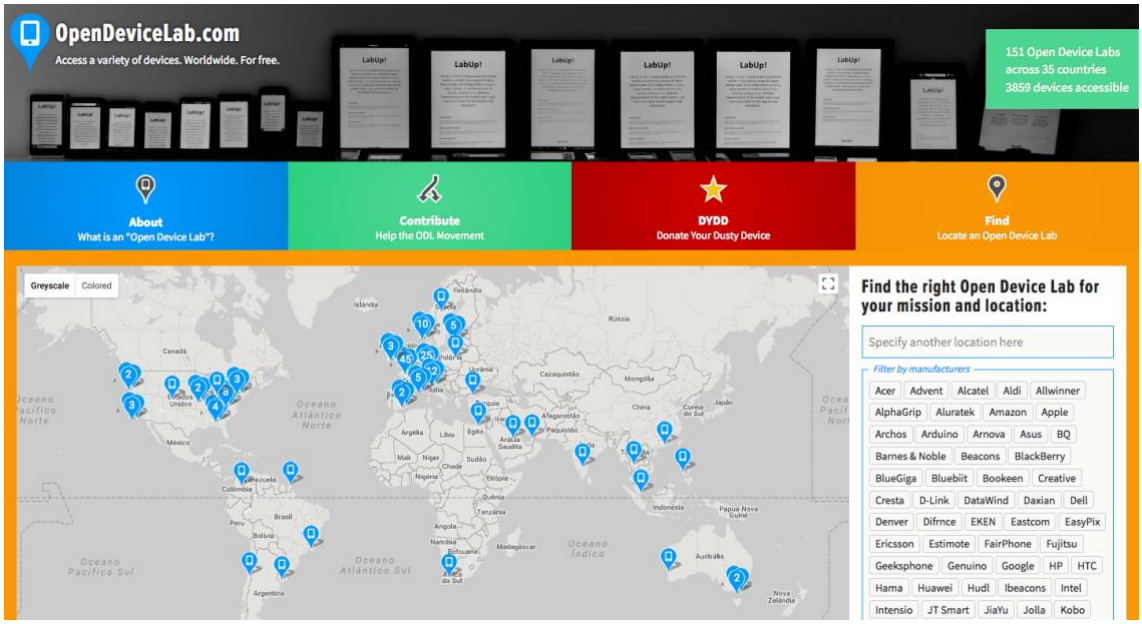

Figure 10 The community's website

Source: opendevicelab.com (2018)

The website was created to be the main channel to locate a laboratory and promote the movement. It is possible to find the community goals, the number of ODLs registered, the scope of countries, and number of devices available worldwide. There is a global map for localising ODLs, based on the user's location, where it is also possible to search by location or by specific device manufacturer. There is information from each ODL, such as name, type, brief description, contact channels (website, Facebook, Twitter, among others), address, number of devices, plus comments with evaluation made by users who have visited the space, see Figure 5. They also make available information on how to contribute with the movement's growth, either to make it visible, donate devices through DYDD, giving suggestions or evaluating the visited ODLs.

– Directory – this is the online list of ODLs registered on the community. Each ODL has a login area to manage their information. Sometimes, guests send comments on closed labs, for example, so when it is known some information is not up to date, the head of the community contacts the local ODL manager.

– Online user review – they decided to implement this section to get help from guests getting in contact, or visiting the labs across the world. Otherwise it would be impossible to verify information on every ODL. This theme is explored in section II.

The Twitter

@odl has been the main channel to publish news on the community. Usually, the posts are about new ODLs registered in the directory and new comments and rating from ODLs' guest users.

The GitHub

This was set up as a GitHub of the LabUp! named ODL-Media-Pool, a pool of free media on ODLs, such as text copy, imagery, logos and movies, on the topic of ODLs. All the material in this pool is convened and contributed by LabUp! and ODLs across the globe.

The communication channels are the most important for the visibility of the movement. It is essential to keep the information both for hosts and guests up to date.

In person meetings – the online tools mentioned before are essential, but in-person sessions give the members other kinds of exchanges. The community has done two meetings in Germany with people from different countries.

The Local

ODLs are physical laboratories typically equipped with mobile devices, such as smartphones and tablets, connected to the Internet and voluntarily offered as a free service to the local community.

In the local, the first objective is to help peers in getting access to mobile devices, to improve their product testing on real devices. In addition, hosts usually are of service and interested in getting to know the guests and their work, making ODLs a rich environment for exchanging knowledge and expertise, while respecting privacy for both hosts and guests.

In terms of service the ODLs do not offer testing and evaluation services. They offer free access to device labs as a type of "self-service". The hosts use the device lab to

test and evaluate their own products. Additionally, external people are invited to use the lab for their own purposes by appointment.

- Props - is about the venue, the devices, the lab as space, software, Wi-Fi, cable and extra facilities like drinks (coffee, tea, water etc.).
- People – refers to anyone who creates, uses, or is indirectly affected by the service.

  Users

  - Hosts – organisations and/or institutions (companies, co-working or education institutes) which host the lab.
  - Guests **–** external people who use the lab for free (individuals or companies such as freelance designers and developers, students and web agencies)

  Collaborators – external software or device companies who support ODLs with free software license or device donations.
- Processes – refers to booking system, communication aspects and devices arrangement.
- User experience - refers to the guest user impression about the ODLs service experience.
- Testing experience – refers to the guest testing experience at the ODL.
- Benefits – refers to the service benefits for the local communities.

In the next tables, we present data related to the use made of device labs by their hosts, private companies, Table 3, and data about the ODL as a service, Table 4,

Table 5, Table 6, and Table 7. Because of the large number of categories, we divided the results related to the service into four tables. The data is presented based on *in vivo* information, using the participant terms as much as possible.

The local aspects introduced in the following sections are more diverse than the global aspects, because it depends on the characteristics of each laboratory and its purpose, which type of company host the ODL. In summary, the results are based on the most common themes found by inductive analysis.

Table 3 ODLs hosted by private companies – data about the use made of device labs by their hosts.

P	Interview date	Country	no. of employees	Type of company	Testing methodology	Testing type	Testing phase	Open initiatives	Device Lab purpose
P1	April 2016	Germany	1-10	Software design agency	There is no specific methodology, it depends on the tester.	UI; hands-on; function; multiplatform; user interaction; touching, inputs, zooming; design breaks.	Mainly during development. At the start of a project or when there are specific bugs. They do not do automating testing with the devices in every life cycle.	Mainly the ODL	Testing
P2	April 2016	Germany	501-1000	Advertising agency, specialised in online marketing	There is no specific methodology. There are QA phases which they use for testing on mobile devices (ODL) and also on PCs (Windows and Mac - not in the ODL). They have different quality gates in which a main part of those are cross browser and cross device testing. This process is repeated until the deployment, and there is also a regression test.	It depends on the project, but the most important are: cross-browser and cross-device testing for functionality and content.	QA phases and quality gates during the project. They repeat this process after deployments.	Mainly the ODL	Creation, production and testing.
P3	April 2016	Germany	1-10	Web & advertising agency	There is no specific methodology. They conduct continuous testing on one, two ot three devices during development. Then there is a short preview to check if it is working; and then they run a big test and do debugging just before the launch.	Mainly performance; compatibility; UI; usability and sometimes accessibility.	Development, pre-launch and debugging.	This ODL was the first open initiative which led to many others.	Testing is the most important purpose
P4	May 2016	Germany	1-10	Web design and development agency	There is no specific methodology. It depends on the tester. They test in parallel while developing.	Functionality; multi-approach; testing scenarios.	Development	A large part of the daily tools and software they use is based on open source. They also participate in open software development.	Focused on testing
P5	May 2016	Germany	51-200	Internet telephony provider	The manager does not know about the host testing practices.	The manager does not know about the host testing practices	The manager does not know about the host testing practices.	They run free events.	Testing; playing around and networking.

P6	May 2016	Germany	50-200	Web technology company	There is no specific methodology. First, the developers build up the application, then write tests and test the product directly on most of devices availabble or through BrowserStack platform. This is the first part. If a feature is ready and if they push on to the pre-production system or test system of a QA, then they test the feature on real devices and they build up a test plan with the UX team. Then, the UX team builds up a feature or design or application, which is expected to work properly. Finally, the quality team test if this feature works.	Unit test; integration test; programming test; concept test; in the cloud test and an exploratory test with users.	Depends on the project. There are testing cases in all phases, but mainly during development and deployment.	They develop open source software.	Mainly for testing
P7	May 2016	Germany	1-10	Digital agency	There is no specific methodology. It depends on the project.	Manual and automated testing; interaction; responsive testing; JUnit testing and Selenium testing are the most common approaches.	It depends on the project. The first testing phase occurs when they start working, then there is a check during development, and a last testing phase before they give the product to the customer to try.	They are connected to the local community. They host events for the local community for free.	Testing and development
P8	May 2016	Netherlands	Self-employed	Web software testing	There is no specific methodology. Everything done is immediately tested on devices.	Basically, it is checking the performance on multiple devices. And they do ad hoc testing on the functionality of the application.	--	They are involved in some open source projects.	Testing
P9	October 2016	Sweden	51-200	Service design and UX digital agency	There is no specific methodology.	Functionality; cross-device; performance.	It depends on the project. In the case of native apps, which they develop with partner companies, they do development testing in the last stages of the project to verify function and bugs.	--	Development and testing
P10	November 2016	Finland	11-50	Digital agency	There is no specific methodology. It depends on the project.	UI; cross-device; performance; debbuging; ad hoc; exploratory testing.	It depends on the project. They test mainly at the end. In some cases they test continuously from the beginning.	They do not make up rules before needed. They do open source development, meet ups and events.	Testing

P11	January 2019	UK	11-50	Digital technology group	There is no specific methodology. It depends on the project.	Hands-on exploratory testing; UI testing; and feature-specific tests; field-based testing.	--	In general, staff are encouraged to contribute to open source projects on GitHub. So they use open source frameworks and similar software in their projects. They also use open data sources. Their business ethos is to be part of the local community. They go to meet ups and run a non-profit conference.	Testing and experiment
P12	January 2019	UK	50-200	UX design and research company	There is no specific methodology. It depends on the project. Designers usually conduct usability research and developers do cross-platform testing. When UX designers have polished digital and interactive prototypes, they run a session with users to test their products on devices.	Usability research; cross-platform.	Usually designers use the devices first, then UX researchers use the devices when they have a digital interactive prototype which they test across different points. Developers use the devices in the building stage. The ideal process starts with user research, talking to users, finding their requirements. Then going away and doing conceptual design, and then making more fleshed out designs. And then testing those designs with users, either on paper or in a tapable form. Afterwards, based on the feedback, they iterate the designs and them test again as many times as they think is needed.	The company host free industry events as a community practice.	Testing and user research

Table 4 ODLs hosted by private companies – data about the ODL service – part 1

P	Cost	How/Why	People	Guest - profile	Guest - frequency of use	Booking
P1	Free	For their own need. The company had a lot of request for Web projects and did not have the devices needed to test on. They bought devices for their own purposes and when they became aware of the ODL movement they decided to be part of it; sharing their devices with the local community. The reason was not to join the community but to offer the devices. Therefore, it was not about the community itself but was about their appreciation for the movement and desire to be part of it as they want to give something back. They would like ODLs to have existed before because they felt the pain of not having the devices.	One driver	All kind of People. Banks, shops, freelancer, and software agencies.	Once a month on average	Booking by email - devices will be prepared - charged on request - and ready to go when guests go to the lab
P2	Free	They liked the idea, wanted to be part of the network and to give the benefit of all devices to others, to share. Sometimes the devices are not used, so why not share it with others? Additionally, to gain contact with others, especially students who use the ODL.	Three to two drivers, QA managers.	Groups from University (students with the lecturer); trainees or apprenticeship - interns from small companies; small companies who do not have their own device pool; freelance developers; school children	Every 3 months	Booking by email - sending which devices will be used, date and time. Devices will be prepared and ready to go when guests go to the agency. They will fill out a form and have a quiet room to test.
P3	Free. There is a box for voluntary donations.	For their own need and at the same time the movement was being promoted. Additionally, to get in touch with others, recruiters and candidates.	Three in the beginning, currently two persons, but one is the main driver.	Most of them are developers, freelance and from small web agencies working on customer/client projects, which use the lab two-three times for the same project.	At the best times (when they used to promote the ODL on social media) there used to be three or four visitors a month, who used to return two or three times for retesting. At other times, more than once a month on average.	Online contact form, available on the website, for booking informing what devices will be used for testing. Once the guest get there the devices will be available and charged, including staff personal phones.
P4	Free	For their own need, but for them seems like a waste having it just for themselves. Invites local peers to collaborate and get to know other people with similar interests, and also to get the networking going with like-minded people to drive the ODL forward. Not only to test but also to solve the community problems.	Two persons, one main driver.	There is no straight profile, but there are more front-end developers and designers. Also quality assurance, and a few visual designers.	One or two a month	--
P5	Free. Unless, for example, a large company asks for a long period of testing on a variety of devices.	Because for them it seems a great idea, they have many devices and experiences to share with the local community. They also think it is great to chat with guests and share experience about building web applications or apps for mobile devices. To get in touch with other developers or other people who have the same problems. To share experiences, and a second reason is to hire good people.	two employees from QA team	Most of them are developers freelance or from small agencies, and some are designers.	One or two a month	Contact the lab, inform which devices will be used for testing. The manager will book a meeting room, check if the chosen devices are available and when the guest get to the lab he will have to sign a responsibility document.

* How/why – refers to how and why the hosts opened their own ODL.

P6	Free.	Because for them sharing is really great and after getting to know about the ODL idea from the first opened lab online post, it seemed a fantastic idea to share own resources with the local community.	A main driver and trainees.	There is no specific group profile but some are freelancers and others are agencies.	It depends. When they used to promote the ODL they got 20 in a week. When they do not promote, it can turn to one guest a month, for example.	Contact the lab by email or phone, make an appointment, and when they get to the lab the guest will have devices and a place to test.
P7	Free.	The driver heard about the ODLs, and had some devices already at the company for testing and for them seemed to be a good idea to join the movement. They renovated the space, bought some devices and opened to the local community. An ODL is good for getting in touch with different people and exchanging ideas professionally. It works like a hub, pushing digital boundaries.	Two-three persons, one main driver.	Most of them are developers, project managers, designers, and freelancers.	It is difficult to say, because sometimes nobody goes, and suddenly everybody goes. Near Christmas or New Year is quite full and then Easter is quite empty.	Guests need to register and fill a form so the company can check who did what and when in case of any security theme.
P8	Free.	The host works with Web testing and got to know about the movement in 2012, which led to setting up a lab because the whole idea of testing on multiple devices is very important and they do not think many companies actually take this seriously enough. Over time it became an own need shared with the local community.	One driver	Web developers who wrote the code and want to make sure it actually works. Not people that are used to testing stuff, not quality assurance or similar.	It depends, sometimes one to two visitor's month, sometimes a bit more.	By appointment only. Contact the host, inform which devices will be used. Once the guest gets to the lab the devices will be available, the host gives some pointers to check for certain things he knows are problematic on some devices.
P9	Free.	First, for own need and second to help local people.	Two persons, one main driver.	Students; Freelancers; competing agencies.	Once every couple of months when they are not promoting it.	--
P10	Free.	--	All employees	Freelancers; web developers.	Once every couple of months when they are not promoting it.	Contact the lab by email, Twitter, or phone.
P11	Free.	Inspired by ODLs in other places and because there was not an ODL in the city, the person who started asked the local community if they would use it as a resource.	Two caretakers	Local agencies and freelancers testing native applications. Most of them are developers. Sometimes there will be a team where there is a designer and a developer. Quite often there is more than one person from small agencies, and some students.	Three a month on average	Booking should be done online on the ODL website, limited to 10 devices, the system is integrated with their Slack period. They receive a message, contact the guest, check their needs and once the guest gets to the lab will have the devices prepared and a private (glass) room.
P12	Free.	Own need, and also it would be nice to share it with the community. They buy the devices to use them as a company, but decided it would be nice for our people to use them.	A main manager, a colleague who will be informed about the bookings, just in case.	Mostly developers or people working with developers from smaller companies. Some people return several times.	Three or four a month. Sometimes it suddenly gets busy, sometimes it goes quiet.	First the guest should send an email to the lab. Then the manager books the room and informs the company reception. When the guest get to the lab he/she sign a usage form, then there will be someone to welcome the guest and introduce her/him to the lab where the devices and the room will be prepared for testing.

Table 5 ODLs hosted by private companies – data about the ODL service – part 2

P	Legal issues	Help	Limitations	Data security	Device selection criteria	Donations	Workstation	Software available
P1	None	Yes, but usually people know what they want to test	There is no limitations, but they are focused on Web testing.	Self-management	Based on the company's projects requirements. Browser and Wi-fi.	Welcome. Devices (most of the devices were donated)	They have laptop available but the guests usually bring their own	BrowserStack
P2	None, but guests have to sign a responsibility document.	Usually not, only If it is needed.	It is not allowed to install software on the devices	The host delete everything the guest may leave on the devices.	New features, screen sizes, based on online statistics (national and international market share) and customers' needs. There are special devices used in-house by customers. The developers are especially interested on trying out new devices to play around and get ideas, and check new technologies.	There is no need for donations.	There is no laptop or PC available for guests	None.
P3	None	Yes, but usually people know what they want to test	None	Everybody is responsible for himself, i.e. after the testing guests have to leave the place as they found including devices settings and erasing data.	--	Welcome. Devices (They received some devices from local companies) and Sync Software license.	They have laptop available but the guests usually bring their own	Ghostlab; JAWS (accessibility-screen reader)
P4	None.	yes, if needed.	They do not limit test scenarios beforehand, but do not allow everything.	There is a a document for guests to sign (not mandatory) which cover the use of the devices for a certain amount of time.	Must be the most popular devices in Germany and Europe, but depends on the project. They use statistics from their client's projects.	Welcome.	--	Ghostlab
P5	None, but guests have to sign a one page document declaring not to do anything bad. It means be a good person and do not destroy the devices, or lock them, or install something bad on it; be a good neighbour in the short term.	yes, if needed.	None		New Apple devices, for example. They use a lot of statistics, client's projects information; a typical market watch, flex store devices, new Nexus and new Samsung Galaxy and the most famous (popular) devices according to data; focused mainly on German and European market.	There is no need for donations.	There is no laptop or PC available for guests	--

P6	None	Yes, if guests get lost, but usually people get around pretty well.	None	They do not have any official paper to be signed, it is a matter of trust.	By request (the most popular); Whatever people donate; other devices besides phones and tablets to play around.	Welcome. Not only devices but also money.	They have laptops available.	Ghostlab
P7	None.	Yes, if needed. It is a good feedback for development and getting information.	None.	They reset all the devices after test.	Normally they buy new devices at market, iPhones, iPads, Galaxy, HTC, and others based on the company needs.	Welcome. Usually devices.	--	--
P8	None	Yes, if needed.	Testing bad network circumstances, because the Wi-fi at the lab usually works quite good.	None. It is usually just trust.	Having a browser that is different, also different screen size, different OS version, different OS	Welcome.	--	Ghostlab and Adobe Edge Inspect
P9	None.	Yes, if needed.	The rule does not allow to install software on the devices. In specific cases it is allowed to install native software on the host devices, but not on the donated devices.	None.	Whatever people donate. The host try to buy common devices or devices that represent things that are harder to test on all devices, a quite range of iOS and Android, from smaller screen to larger screens. Also different OS like Windows phone and old Firefox. And at least a few devices with older versions of iOS. In resume, as much variety as possible. They do not look much statistics because that is the present but not necessarily the future.	Welcome. Devices (They received some devices from local developers)	--	--
P10	None	If needed. Usually it is self-work	None	None.	Ask clients, employees. Whatever people donate.	Welcome.	--	BrowserSync
P11	None.	If needed. Usually it is self-work	One booking per day from Tuesday to Thursday	self-management	The company buy new devices to the market (iOS and Android), check clients data, get some donations from individuals, and also popular devices from a partnership with a local company that are focused on devices and once they become unused they give to the ODL which store and use them.	Devices and software license	--	BrowserStack
P12	Guest must sign a confidentiality and responsibility form before using the lab.	Yes, if guests get lost, but usually people get around pretty well.	Guests cannot update the devices operating system.	self-management	Based on the demand of the people working at the company, and also the market demand like a new phone with a new feature.	There is no need for donations.	--	None.

Table 6 ODLs hosted by private companies - data about the ODL service – part 3

P	Device loan	Testing native apps	Testing games	Maintanance	Running - unexpected happenings	Online - up to date information
P1	It is not the host preference but it is possible.	Not focused on it, but it is occasionally allowed.	Open to but it has not been a use case.	There is not a lot to maintain; They do not invest a lot of time on it; They prefer to keep old software because it is harder to find.	Guests are usually thankfully and positive about it; they like the idea. **Visit from a big group from a University.	yes/yes
P2	Not allowed for ODL users. Just the employees make use of the devices outside the company, for their own purpose, for teaching or helping a specific project.	In each device during the cross-device test.	There are no specific consoles, but it is allowed to test games. There was no mention about specific cases on games.	They do it daily for themselves, so it become easy also to the ODL. Also when there is a new OS version or new devices to buy. They keep the OS updated with old and new system. They have in-house booking system for device loan.	--	no/yes
P3	Allowed.	They do not work on it but guests tests in each device.	Allowed.	--	They learn a lot about what guests are doing, different projects being tested like Web-based digital magazine interactive stuff.	yes/no (Device list is not up to date)
P4	It is not the host preference but it is possible.	They do not work on it, but there were guests testing native there.	Open to but It has not been a use case.	They do not update the ODL devices to the latest operating system, only the personal devices. The charging of the devices is made by a system which turns on and off, in intervals.	Device donations from other country and a large project came out after showing the ODL for a client.	yes/yes
P5	It is not the host preference but it is possible.	Allowed. They have continuous integration for testing native apps but in the QA team they install it and they also test the start process, and also do a manual test with humans.	Open to, mainly for Web-based games.	They have an internal system (open sourced software) to check the devices available and in which office they are, because they share the devices between two offices, like a library.	--	yes/no (Device list is not up to date)

P6	Allowed	Allowed.	Allowed, but It has not been a use case.	It is not structured at the moment. Everybody knows where to find what.	None	yes/yes
P7	Usually not allowed.	Allowed.	Allowed, and there were some cases.	Part of the job of the company	Getting guests at the opening party	yes/no (Device list is not up to date)
P8	--	Not focused on it, but it is occasionally allowed	Allowed, but It has not been a use case.	Devices are the hardest part, checking once in a while if every device works overtime, keep the OS version. And dealing with people is the easiest part.	Get visitors	yes/yes
P9	It is not the host preference but it is possible.	Not focused on it, but it is occasionally allowed	Allowed, and there was one browser based test game case.	--	--	yes/no (Device list is not up to date)
P10	--	Not focused on it, but it is allowed	Allowed.	Plug the device pool in the electricity which are always charging, get a new Wi-Fi station to so many devices. And reset phones before and after guest use.	--	yes/no
P11	Generally it is Not allowed.	Focused on it.	Allowed, and there were some cases of game testing.	Not complicated, there is a separate network and the devices (a large number) are stored in cupboards.	People get in contact but do not understand that it is free.	yes/kind of (some info might be updated)
P12	Not allowed.	Allowed.	Not that they know.	They have an internal booking system where the manager can see who booked what and keep these charged.	A guest brought a lot of donuts to the team as gratitude.	yes/yes

Table 7 ODLs hosted by private companies - data about the ODL service – part 4

P	Collaborators	Academy-industry relationship	Community connection	Open Labs connection	Community main advantage	Community expectation	Space
P1	Mainly device donations by tech companies	Open to, but not seeking for it.	Low contact - by email or Twitter	None.	An open and friendly community which is not money driven and people are happy to help other people.	To keep growing also in small towns.	Private room
P2	None	Some employees are lecturers at the University and also collaborate with educational projects which allows the use of the devices outside the company.	Minimum - there is intention, but there is no time for it.	None.	They are not interested in the ODL community in the first place, so they do not interact with the community that much. They only wanted to share the devices and like the idea of getting in contact with peers (web developers, freelancers, students, people working with digital creation and online marketing).	There is not much expectations, they hope it continues growing to give opportunity to others.	Private room
P3	Local companies	There were people from the university testing there and some interested from a lecturer on it, but not so clear at that moment.	The community is quite well connected mostly in Germany and in Europe. They are part of the community core and are a strong node	No concrete action	First they feel good to give something back to the Web community; from where they got a lot of knowledge. Second, to share the devices with others.	They do not have any expectations regarding their own ODL. It is there and they are happy if someone can use it.	Private room
P4	Not regular. There are specific contributions like a lawyer supporting legal issues; software licenses like Kirby CMS and Ghostlab, and people who donated devices.	None	There are strong relation with specific ODLs and people attending the same conferences.	None.	They feel good to give back to the community and also to have contact with people who are interested in the same topic, and from a business perspective, it is kind of a marketing tool.	They do not have any expectations. It seems there are different initiatives, in-house device labs and seems to be demand for institutional financed labs.	Open private space
P5	None	There are connection with the host, but not specific with the ODL.	There are occasional contacts.	None.	To talk to people and get a big network	They do not have any expectations	Private room
P6	Mainly device donations by tech companies	None at the moment but intends to - time issue.	They are well connected.	None	The voluntary principle, a big advantage to people who have no money but want to bring and push stuff forward. Community is the best thing to drive ideas, to make it real.	No expectations because it is voluntary and needs time to go forward.	--

P7	In the beginning they got devices from some hardware manufacturers.	None.	There are occasional contact.	None.	It is nice meeting and exchanging with other developers who have the same demands. It proves that this is something that makes sense, connect people, business wise, professionally, and personally. To get together, exchange ideas and help each other. It helps shape the future in a small sense.	No expectations, but hope it grows and people get more open and help each other and enjoy it.	--
P8	Mainly device donations by tech companies	None	Talk to other participants at conferences	None	Commercially it doesn't have any advantage, because it takes time and money. Although, personally it's been a success, because he thinks more people should do testing and more people should test on multiple devices.	On one hand it could be more successful, because there are still too many people who do not know about this. On the other hand, over the last three years the ODL movement has grown immensely. Hopefully many more people will start using ODLs	--
P9	Devices donated by local developers	Not the ODL, but the host which is also trying to become more active in the Education world.	Besides knowing two ODLs managers, there is not specific connection or collaboration.	--	The principle of sharing is important for the whole industry. And ODLs can reinforce this type of culture within the Web world. As company that hires developers it's important to keep connections and be networking with other developers in the region too. Because they depend sometimes on freelancers, for example. And also it's a goodwill gesture to the local developer community, a win-win, mainly to small companies which can't afford to have an ODL.	They don't have any expectations. They use it in their day job and do not have any specific time set aside to convince external people to do the same. Although they would be happy if more companies use the lab. It's a good thing and hope it continues.	--
P10	Mainly device donations by tech companies	Individual cases with students	None	--	Give back to the community.	Improve things, get more visitors, but not much (weekly or monthly), and get more device donations.	Open space
P11	Local tech company (devices), hardware manufacturer, and software license.	The company works with the local University, in the visual communication course. They take one unit, sort of a small project for them (over three weeks) in which they talk about mobile device testing, tell the students about the lab, and invite them to use it. In the comany opinion it is important for students to learn that there is more than just their iPhone to test on.	They were in contact with the main community driver in the beginning.	--	To engage with the local area in a positive way. Bring devices not widely available in as a way to make people engage with future devices. For the company having many devices on hand is very useful and instead of hide them they make it available for everyone. And get them well known in the area.	They are thinking about expand their ODL	Private glass room
P12	None	The company have an internship program.	None	None	A feeling that they are helping out others in the community; the dynamic nature of the community rather than a benefit that they get.	Just keep doing it.	Private glass room

Considering all the data analysed in this PhD thesis, we present a resume of the characteristics of the **most straightforward ODLs, which are:**

a. device labs already established for the host's own use and shared with the external community as a free service.

b. an idea of the CEO, chief, boss.

c. a key resource for own use of the host.

d. primarily or completely funded by the host.

e. part of the Web design community.

Those who have struggled with opening and keeping open long-term ODLs, are those which are:

a. an idea that has not come from the 'top'.

b. not a key resource for the host.

c. run by just one driver – all the effort is made by one person, setting up, management, promotion etc.

d. primarily dependent on donations – more and more people sell old devices or give them away in exchange for a new device, and 'old' hardware and software supporters of the community are no longer helping the new ones.

e. not part of the Web design community, where people do not usually understand why they share resources for free.

This section described and explained the ODL's glocal ecosystem and presented the main characteristics, practices, benefits and challenges. In the next sections, we present three studies which addressed: a) additional information about the ODL's ecosystem from the guest user's perspective, b) how the ODL's community can benefit the game industry, c) how and in what ways an ODL hosted by an educational institution works. And lastly, in section V we present a framework for academic ODLs.

II. Online User Reviews as a Design-Strategy for Global Communities: Contributions of the Open Device Labs Case.

Manuscript published in International Journal of Interactive Mobile (iJim) on 15th November 2019.

Godinho-Paiva, Raquel; Contreras-Espinosa, Ruth. S. (2019). Online User Reviews as a Design-Strategy for Global Communities: Contributions of the Open Device Labs Case. *International Journal of Interactive Mobile Technologies (iJim).* Volume 13. Number 11. November. 10.3991/ijim.v13i11.11042

III. Game testing and evaluation on real devices: Exploring in the case of the Open Device Lab community

Manuscript published in First Monday Journal on 5th August 2019

Godinho-Paiva, Raquel; Contreras-Espinosa, Ruth. S. (2019). Game testing and evaluation on real devices: Exploring in the case of the Open Device Lab community. First Monday. Volume 24. Number 8. doi: 10.5210/fm.v24i8.9525

IV. Web, App and Game Testing and Evaluation on Real Devices in Higher Education: An Irish Open Device Lab Case Study.

Manuscript under review at Information Journal

Godinho-Paiva, Raquel; Contreras-Espinosa, Ruth. S.; Horgan, Claire (2019). Web, App and Game Testing and Evaluation on Real Devices in Higher Education: An Irish Open Device Lab Case Study. *Information Journal.* (in review)

V. The Framework

The Framework

In this section, we will define what an academic Open Device Lab is as compared to professional ODLs, and propose a framework for long-term activity. The framework for academic ODLs aims to provide guidelines on how to set up and run an ODL for long-term activity focused on teaching and learning practices. The framework is not a manual, it intends to help practitioners with guidance about the main opportunities/benefits and the challenges/obstacles.

In the previous sections, we used the terms ODLs hosted by private companies and educational institutions, or educational ODLs. At this point we categorise ODLs in two main categories according to type of hosts, professional and academic Open Device Labs, see Table 8.

Table 8 The main characteristics of professional and academic ODLs

Professional ODLs	**Academic ODLs**
They were the first type of laboratory to emerge. The majority of the labs registered are professional. They are focused on providing access to devices as a resource primarily for expert testing. They are usually hosted by private companies.	They emerged later. There are few academic labs. They are focused on supporting primarily higher education disciplines related to human-computer interaction (HCI), based on a hands-on approach. They are usually hosted by university level institutions.

What defines an academic Open Device Lab?

An academic Open Device Lab is an ODL typically hosted by an educational institution, such as a university, college or school to support both the internal and external local

community in teaching and learning, research, and market practices related to mobile testing and evaluation.

Objective(s)

An academic ODL aims to support mobile testing and evaluation projects related to academic activities such as education, research and development. These labs aim primarily to support teaching and learning practices related to higher education disciplines. An academic ODL might be a space to experiment, learn, evaluate and test, connect and collaborate.

Examples

Currently, there are 10 ODLs hosted by educational institutions registered on the community website. Although six of them do not have an online presence anymore, which means their websites are no longer available. In the first phases of the research, we wondered whether those labs with websites offline were not up to date or would be closed, but we found out that this is not always the case. For example, the ODL IT Tralee websites had been out to date for a while and recently became offline; this is because the ODL team can only maintain local actions and for the moment are not able to maintain an online presence.

Table 9 ODLs hosted by educational institutions

Name	**Country**
*Open Device Lab Institute of Technology Tralee	Ireland
IdeaBase User Experience Testing Lab	USA
YSU Open Device Lab (YSU-ODL)	USA
ODL Uvic	Spain
POPSchool ODL	France
*DevLab - Hosted by UCL Advances	UK
*odensedevicelab	Denmark
*ODL@PSU	USA
*Cologne Open Device Lab	Germany
*ODL Brussels	Belgium
All these labs are resident ODLs. The * indicates the labs which do not have active websites or webpages.	

The academic Open Device Lab framework

After more than six years since we became interested in the ODLs and four years after conducting research on the global movement, we have seen a variety of scenarios related to setting up and running Open Device Labs. The research findings have shown that besides professional device labs, the setting up of an ODL is as important as its plan for long-term activity. Despite the straightforward ODLs, there are many labs that have not progressed from the planning phase and many others which do not have a long-lasting life. For this reason, we built a framework, see Figure 11, for helping in the establishement of academic ODLs based on a) key practices and lessons learned from the most straightforward ODLs, b) those who have struggled with opening and in

keeping open long-term, c) the five life stages of non-profit organisations (Simon & Donovan, 2001) presented in the background section.

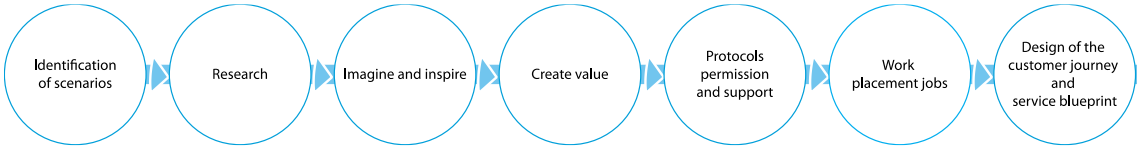

Figure 11 The framework for establishing academic ODLs

Source: author

Phase 1 Identification

Identify yourself in the scenarios:

Scenario I – I want to set up an ODL from the scratch.

I work in software development and thus, gained knowledge about the Open Device Labs. I think it is a great idea and I would like to set up an ODL primarily for the local community.

→ Okay, think about it as a start-up service non-profit business. We do not address this scenario in this thesis.

Scenario II – I want to share my device lab with the local community.

a. I am the responsible for an organisation or institution, sector or department, and for any reason we have a Device Lab for our own testing and evaluation purposes and we want to share it with the local community

→ Okay, this is the most straightforward scenario for taking off fast and having a long-term life, although there are things to consider before doing it.

b. I am not responsible of any organisation or department but the place I work for fits the same scenario.

→ Okay, it might not be as easy as the scenario II-a, but easier than the scenario I; even more so if the host will be a private company like a digital agency.

The issues for these scenarios are mainly addressed by published information on the LabUp.org.

Scenario III – I want to set up an academic ODL.

Phase 2 Research

Understand what an ODL is and your local community (internal and external). Look at the advantages, disadvantages and main issues of setting up and running an ODL. It might need more than one year before starting to implement anything. After this, if you still want to move forward go to phase 3.

Phase 3 – Imagine and Inspire

Decide if it is worthwhile to pursue setting up an ODL.

Phase 4 – Create value

Develop and define a minimum viable product (MVP) concept. Those who want to set up an academic ODL usually understand the value of having a device lab for teaching and learning practices are based on openness principles and see the value of sharing resources with others. Although, the setting up of teams frequently do not have the support needed to implement a lab. It is valuable to start with a minimum viable product (MVP) concept as a pilot both for those who want to establish an ODL and those who will authorise and be involved in the ODL establishment; those in the upper levels of the hierarchy, departments and university directors. We recommend starting with the development of a MVP for Web testing and evaluation because it is easier, but it will depend on the host primary needs. To do it, ask yourself:

What do WE want to support?

- Web-based products
- Native apps - Android
- Native apps - iOS
- Hybrid apps
- IoT
- Others

Legal issues – This is a hard topic to address, mainly because each country or state follows different rules. Many ODLs researched about setting up the lab as a non-profit organisation, but found in practice that it was not worth it and they do not complete this step. In practice, there are three main practices:

- Everything is made based on trust
- The guest signs a specific document in terms of "responsibility" to use the lab.
- The guest signs the same document in terms of responsibility as the internal community (staff or students).

Phase 5 - Protocols, permission, and support

Get the institution permissions and financial support. A MVP concept will help in getting the permissions to a new project implementation. Do not go forward before this is obtained.

Phase 6 - Work placement jobs.

Offer work placement(s) for student to establish the lab based on the MVP defined in the phase 4.

Phase 7: Design of the customer journey map and service blueprint.

Creating a customer journey map and service blueprint might be a valuable strategy to the people, mainly the students, running an ODL. These strategies help in visualizing the relationships between different service components (such as people or processes).

Important - If any basic variable (people or time or funding/budget) have run out, the services should pause the incremental delivery cycles until these conditions are re-established. In the minimum case scenario, the lab will be ready for Web testing and evaluation.

Lessons learnt

- It is very common that people in general get excited about the ODL idea but usually the majority of them do not actively get involved in the setting up, running and support. Help in any way, in the setting up and the running it is more about moral support.
- Do not do it alone. Find people who primarily benefit from it and get advantage from their input.
- Get to know what are the challenges before to start taking action.
- Ask yourself, how long are you willing to volunteer in this project?
- Get someone paid or rewarded to be responsible for it.
- Plan a system that is as independent as possible.
- Document as much as possible.
- Be open and clear with your local and global community about what is going on. For example, if the lab needs to close permanently or temporarily, inform this situation through the same communication channels you have used to inform the ODL opening.
- Until the present moment, there is only one type of ODL that has a long-term life, device labs shared for free with the community.
- You need a team and an annual budget. In practice ODLs do not work anymore based on donation; neither in terms of hardware nor software.
- Team project – a long-term sustainable ODL is too much for one person to control.
- No external funding or budget – the host is the provider.
- Do it first for yourself as an individual or an organisation.
- There are two main options:
  - A ready to go device lab to in-house testing – It is the most common.
  - A pool of devices for loan based on a library system.

Setting up the lab – processes and props

Permission – unless you are the CEO or equivalent in the organisation/institution, a permission to set up the lab is the start point. Many device labs proposed by people who need permission take years to open the doors and, a few times, it did not happen.

Location – in theory, a Device Lab can be located anywhere. Many times, it is not easy to find the perfect location for setting up the lab. If you can choose you are lucky, try to find the best place to your users, remember you need to attract users (both the public and business). Keep in mind it will be easier if you find a location which can support you in terms of infrastructure and is an easy or central location for your stakeholders. If you are not setting it up at your organisation or institution, sharing a space is recommended, consider a library or another kind of lab (Fab Lab, Living Lab, University, School), or co-working. Finally check if you need any permits, permission or license, avoid complicated (strict) places, and invest in locations, which already have some kind of openness.

Support – there are some options to funding and you may choose other ways. It will depend on your purpose.

Completely funded by the host – it is the most commonly successful option because the company set up the lab and keep it running primarily for its own benefit and secondly to benefit the local community.

Sustainability – think about long-term sustainability. It is a challenge to keep an ODL after a few months of running and maintaining enthusiasm.

Finally, you will need to sign up and register the ODL at labup.org. The requirement is to have a website or webpage with information about the new ODL.

Lab maintenance

The following categories comprise the main issues to take into consideration about maintenance.

Booking – most of the labs manage the booking by email. Usually, they need to know which devices, from the device list available on their website, on which the guest

wants to test. Having the information about the date, time and selected devices to test on helps the host get the lab ready to go for the guest.

Devices – donations are uncommon practices, so it is essential to have a minimum annual budget to get more devices, new or old ones. They are the core of the device lab so you will need at least a few smartphones or tablets to start. They do not need to be new ones as refurbished or donated devices are good options.

Infrastructure – besides the devices, you will need cables and chargers. In addition, it is recommended to have a private room or space as well as a dedicated network for the guest. Security is one of the most concerns for both hosts and guests.

Community directory – keep the information up to date on the global list apart from the ODL website. The directory is the main channel for people to find your lab.

General Discussion

General Discussion

In this section, we present a general summary of the results, the discussion, the strengths, the limitations and challenges, and the implications and recommendations for future research.

Main Findings

This PhD thesis presented the first research on the Open Device Lab community movement contributing to a broad range of evidence about its ecosystem, main characteristics, practices, benefits, and challenges. This study intended to explore the ODL ecosystem in a comprehensive manner and not to be exhaustive; an exhaustive study would not be possible.

ODLs are a grass-roots community movement based on a specific approach that tries to facilitate access to device labs and democratises testing and evaluation on real devices. The movement emerged in 2012 in the Web development community spread across the globe, in 35 countries, and later reached the academic sector. At that time, testing on at least a few phones was unavoidable (Grigsby & Gardner, 2011). However, market surveys have shown that this is not still a mainstream practice. We have already presented in the initial sections that only more than half of the respondents reported testing on mobile devices (Smartbear, 2018). On the basis of our findings, we may argue that people do not test on real devices partly because they do not have access to do so. The findings of the literature review, the ODL guest user experience, the interviews, and the field notes showed that having access to real devices is a valuable resource for improving mobile digital products, and for the ODL user guest, an enriching experience.

In 2015, when we started this research, ODLs were mentioned in the literature on mobile development, but there was lack of information about them. It appeared to be a well-known concept, but outside the Web design community, it was not so. On the one hand, it was an opportunity to make an original contribution to the field, and on the other hand, it was a challenge to define the focus of the research because of the number of possibilities and the limitations. Then, we decided to move forward on the

basis of our interests, ODLs, games, and education, depending on the actors' responses and open doors while managing limitations such as time and budget.

As a case study, the arguments presented in this thesis are particularisations and not generalisations, related to the ODL ecosystem. If we compare the findings in terms of what happens globally, they are more homogeneous than those observed locally. In the local communities, ODLs have common elements but multiple different implementations. Furthermore, our arguments related to ODLs might be applied to other open labs networks as *petite generalisations* (Stake, 1995). Our intention was not to generalise, what the reader will see in the following paragraphs was a practice of using information from other open labs networks to elucidate characteristics similar to those found in our data analysis. 'There is emphasis on uniqueness, and that implies knowledge of others that the case is different from, but the first emphasis is on understanding the case itself' (Stake, 1995, p. 8).

In this context, a comprehensive study was presented, based on original research papers which addressed the global community, host and guest perspectives, and new emerging branches, academic ODLs, and game testing and evaluation. The **literature review** makes two main contributions: (1) from secondary sources, the evidence about the need for testing on real devices in mobile development and the presence of ODLs in the list of the more common approaches for testing on a large number of devices (ASTQB, 2015); and (2) the gap about the Open Device Lab community movement both in general and in emerging themes such as education and games. Due to our backgrounds as researchers and lecturers this thesis explored not only the general community aspects but the emerging themes. The online data from primary sources helped in obtaining the initial and general information about the ODLs, such as the organisation of the movement, history, proposal, and main actors. Then, the results were presented in five sections to better address the specific themes of the ODL ecosystem. **Section I** presented a comprehensive view of the Open Device Lab ecosystem. The findings revealed two key aspects, the local and the global. **Section II** provided evidence about the guest user perspective of the service experience. **Section III** examined the laboratory's service to help the gaming industry test on real devices.

Section IV presented a single case of the ODL hosted by a university-level institution and its characteristics, practices, benefits, and challenges. Lastly, in **Section V**, we presented a framework to help to establish academic ODLs.

Discussion

The literature review placed the Open Device Labs in the context of their contribution, testing, and evaluation on real devices, but there is still a lack of related conceptual frameworks, paradigms, elements, actors, and characteristics. Because of this, this thesis was not only about mobile testing and evaluation issues but also about the open and collaborative community ecosystem of the ODLs. This is also the reason that we chose to focus more on the case than on the testing issues. The aspects discussed in the papers presented in Sections II, III, and IV will not be discussed here again. This section focuses on a general discussion about the thesis findings.

The Open Device Lab community movement ecosystem

In an age of a vast number of studies on online communities, we observed during this research, a tendency to perceive the ODLs as an online community. Our findings showed that this is a misunderstanding. The Open Device Lab community ecosystem is characterised by local activity and global connectivity. This makes *glocal* (Wellman & Hampton, 1999) an essential concept for understanding the ODLs. Glocal emerged as a key category in this research. Online data on the global community were accessible, but the data on the local activity were considerably more difficult to access and were limited. There are participants working with clear policy doors and others who appear to not do so, at least not in the same way. Therefore, we pursued data about the local activities, as we persisted and reached participants willing to contribute to this research. Some of them did not understand our interest in getting to know about the local actions in their communities. Sharing and exchanging with peers is something obvious and natural for them, including their own physical resources. Then, we found out that they do not usually register data about guest users; they are not interested in doing so. They are interested in helping, meeting, exchanging, connecting, and sharing. Therefore, for this PhD research, local actions became increasingly important. We

started collecting and analysing data about the global community, and then accessed the local activity data, first by the core of the community observing in-person activities and participating for a short period in their environment and then, finally spent two months in an ODL. The single case study, which might be seen as of little value for some, is a key and valuable study for this PhD research. The common elements with multiple different implementations adopted by different laboratories are the components of the global ecosystem. Thus, the global ODL community connection and management occurs online and the ODL service occurs in-person in the local communities. The most important actions of ODLs occur in the local environment, in physical labs, face-to-face, and in-person where the primary goal of the movement is achieved, to make testing on real devices possible for a greater number of technology professionals and 'ultimately improving the Web and app experience both for developers and consumers' (ODL, 2018). This is what makes the actions in-person, in the local community, as much as or more important than the actions online related to the global community. The online actions are focused on helping peers find an ODL, explain and promote the movement, attract supporters, and face common challenges in the setting up and maintenance of laboratories.

The data analysis revealed that the global movement would not reach its extension without the online directory and the actions of promoting the idea on blogs and social network sites (SNSs) (Boyd & Ellison, 2007). The promotion was not made only online, as many of the active actors in the movement are frequently invited to talk at international Web conferences, in different countries, where they speak about mobile testing and introduce the ODL idea. Some participants got to know about the ODLs at Web conferences, others from Jeremy Keith's blog post on opening the doors of the first lab, and the others from Twitter. And when the question: Why do some labs work and some do not? emerges this PhD thesis first answered in the section I with summed up characteristics of the most straightforward labs and those who usually struggled with opening and in keeping open long-term. In this section, we ultimately argue that it is because of their business ethos and community principles.

Openness, sharing, collaboration, and design principles

Principles are the key to developing practices that lead to processes (Rosen, 2007). In the ODL case, the openness principles lead to sharing and collaborative practices in terms of resources, knowledge, and expertise. Furthermore, the ODLs are an extension of the Web design community which the actors, first involved in the ODL movement and the most active, are a part of.

The Web we have today is a result of an initial project written by Tim Berners Lee to solve the problem of sharing information. The openness of the Internet allowed Tim to build the Web, and the openness of the Web is allowing people to build a variety of things (Web Foundation, 2017).

This PhD thesis identified that there are many participants of the ODL community who are affiliated to the Open Web standards and design principles (W3C, 2017a), Web for all and on everything. The revolutionary ideas of the early Web community, namely decentralisation, non-discrimination, bottom-up design, universality, and consensus, have spread far beyond the technology sector (World Wide Web foundation, 2008). However, there are people from the technology sector not yet engaged in these ideas. This mix of people who are connected to the Web community principles and others who are not is also found in the ODL ecosystem. Because there is a common goal of sharing devices for testing, other aspects such as their principles are clouded. Some participants registered on the online directory appear to not follow the same collaborative practices as the core of the community.

Main challenges

The evidence showed that setting up and maintaining an ODL is a recurrent issue in the community. In addition, establishing academic Open Device Labs is harder than establishing professional labs. The findings showed issues with institutional protocols related to authorisations, software and hardware purchase, and security concerns about the equipment. All the four academic cases helped us gather more information than that available online, showing that the establishment of the lab took at least

more than one year. Moreover, two of them did not open the doors for their local communities, only working as a device lab, and the other two in terms of activity relied on one driver, which adversely affected the long-term effectiveness of the lab. Our experience, as participant-observers, confirmed the previous findings. For example, it has been over three years since we have been trying to set up the ODL UVic. We have been making efforts to get the ODL UVic working independently as soon as possible. This was the main reason to set up the lab at the faculty library. The online and in-person booking systems of the mobile devices are working well and are similar to the book loaning system. In this journey, we have met many driven people who have supported this project. However, at the same time, there have been some limitations in terms of budget, people, and value. Establishing an ODL in an environment without the same principles has proven to be difficult and not very effective.

Marcotte (2017) said that a device lab is a design tool to verify the designers' assumptions and to get people to care about the users. An ODL might be seen as a resource where users can test their applications (Horgan, 2019), but from our findings, we can define an ODL as a primarily free service available to everyone but used mainly by technology professionals who do not have their own design tools. This is a key aspect that helps in understanding what it means to set up and run an ODL. ODLs encourage people to help peers to improve user experience of digital products and services. Thus, these findings elucidate how the ODL ecosystem works. This is the basis for deciding on whether to move forward and set up an ODL and maintain it or not.

Open Labs Networks

Intrinsic case study research does not require a comparison with other cases. The PhD theses that we presented in the background section about Fab Labs and Living Labs did not make comparisons with other communities. We attribute this to the fact that they had previous studies on the same theme to rely on and had many issues left to address. In this PhD case study on ODLs, the case is completely different. This research is the first initiative to explore the community movement, and therefore, a comparison

of ODLs to other open lab movements was of great value. ODLs have a different purpose from Fab Labs or Living Labs, but as mentioned in the background section, they match the LSCI-specific characteristics. ODLs are not precisely in the same category of creative and open innovation, but they match the three common characteristics of LSCI and share principles such as openness in the interactions of communities and organisations. A unique aspect of the ODLs is their focus on software quality assurance. In addition to the common characteristics mentioned by Capdevila (2013), we found similar characteristics and challenges between ODLs, Fab Labs, and Living Labs. For example, inactive or 'dead' labs are not an issue only of the ODLs. Schuurman (2015) found that at least close to 40% of the 345 Living Labs registered in the European Network of Living Labs (ENoLL) were inactive or 'dead'. For the author, this fact raised questions regarding the sustainability of the concept.

The ENoll was founded in November 2006, and from 2010 onwards, the number of new Living Labs started to drop. Currently, there are over 150 active labs in 20 of the 28 European countries. Schuurman (2015) argued that the drop can be partly explained by the fact that in 2010, the admission criteria and the review process became relatively strict. Something similar happened in the ODL movement, which reached 157 labs registered four years after the establishment of the first lab; then, this number started to drop. Currently, there are 150 ODLs in 34 countries. Although, it is important to highlight the differences between these two situations, ODLs do not have an association managed by an executive board and do not have a strict admission criterion or review process, like Living Labs. Our findings suggested that inactive or 'dead' ODLs are partly explained by a misunderstanding of the purpose, lack of information about challenges and labs that do not take off, and different principles. For example, many people worry in advance about the possibility to have a high number of bookings to the ODL, but first, this is not a common scenario; second, the hosts manage bookings according to the organisation's availability; and third, the demand for the ODL usually increases when it is promoted on the SNS. Another difference is that Living Labs consist of people, academia, industry, and the government, while ODLs do not have a partnership with governments.

ODLs' current situation and future scenario

Currently, it appears that the global movement and LabUp! are in standby and from our findings, we can state that there is a need for a 2.0 version, a redesign for sustainable local labs and for the global community that has been for a long time maintained by only one person. Moving forward, the LabUp! 'future' plans, presented in Section I, that have not yet been implemented seem to be a requirement to possibly lead the movement to a new wave of sustainable labs. However, first, it is important to identify hosts who are still interested in it and in what way; and what are the current demands from both the hosts and the guests. The whole community has many different approaches to be considered for a step forward on creating a new model for the movement's sustainability.

With respect to the future, as presented in Table 3 and Table 7, the ODL members do not have many expectations. On the one hand, ODLs are a project aligned with their business ethos to be part of the local community. On the other hand, this is a non-profit project run as a side project. Therefore, they have been positively surprised by the number of laboratories that have opened in the past few years in a large number of countries. They are part of a community which is ahead of our time because of their intrinsic capacity to collaborate, early revolutionary ideas, and fight for a free and better Web and app experience for everyone and on everything.

From our perspective, shared ODLs are still an important contribution to local communities even if they offer a small-scale free service for personal testing. Academic ODLs have a high potential to benefit a relatively large number of people including citizens and to optimise a device lab concept offering a greater diversity of devices, such as mainstream and unique market devices, and old and new devices, for experimenting, designing, testing, and evaluating aspects related to interaction design and human–computer interactions (HCIs).

Triangulation

We found coherence between data from the literature review and the inductive results that we obtained. For example, there was consistency between the information presented by (Peterson, 2014), that some ODLs were company laboratories opened to the community, others were hosted by private companies, and others were in co-workings or non-profits, and the interviews we conducted. Although, we did not find labs officially registered as non-profit organisation, only attempts to do it.

Games did not emerge as a theme in our literature review, but this theme emerged later in the document analysis. We addressed Game testing and evaluation in Section III.

In our findings from user reviews analysis, there were not so many mentions of the benefits of networking as there were in the student interviews we conducted. On the other hand, the user reviews analysis brought up more information related to the benefits of knowledge exchange and expertise sharing than in the academic ODL case study. In addition, setting up issues was a category not mentioned in the user reviews data.

Ethical Considerations

According to Yin (2017), when conducting case studies the most desirable option is to reveal the identities of both the case and the individuals, but within limits that protect the human subjects. In this investigation, the object of study being an open-ended community may have made it easier to obtain the permission of its informants. Therefore, different strategies were used, for example:

- Contacting the manager, who was the main representative of the community, to request information and present our intention to conduct research on the subject.

- Informing the members of the community about the research being conducted, and presenting ourselves, the researchers, through the community online newsletter and Twitter, with the manager's help;

- Contacting members of the community to participate in the interviews, mediated by the community manager;

- Consulting the doctoral school and the ethics commission of the University of Vic to ascertain the need for formal permission for our investigation.

- Preparing a consent document for the use of the information obtained in the interviews where the participant could choose between anonymous or known consent, Appendix VI.

Strengths, Limitations and Challenges

The strengths of this PhD thesis are based on rigorous, ethical, and credible qualitative research design principles, as a suitable and comprehensive approach to reach the aims of the thesis, and to make a significant contribution. The rigour of this research is based on the choices made related to theorethical constructs, data and time in the field, selected samples, context analysis, and data collection and analysis processes (Tracy, 2013).

Limitation - Observing a contemporary phenomenon in its life cycle takes more time to understand and defines it. The limitations of this research were: a) the lack of literature on the object of study b) difficulty to get access to the ODL hosts c) lack of opportunity to get in touch with more ODL guests d) lack of data registered by ODLs.

The main challenges were to get in touch with the participants. We could contact some ODL's hosts but some of them did not answer. We could reach some informants and could interviewed others due to our insistence and with the help of intermediary contacts. There were interviews that took over a year to be scheduled, and there were persistent attempts that did not result in feedback. Other limitation refers to the fact that ODLs usually do not register data about the use of the lab either for their own use or by the guests.

This study did not use netnography although, we considered Kozinets (2010) recommendations about the difficulties that the researcher encounters when trying to approach a community and its members essential to researchers. After many failed

attempts to get feedback from hosts, we followed Kozinets recommendations such as refining the approach and connecting with potential informants, showing them the importance of their collaboration to understand a common theme and trying to use their language.

We tried to interview an increased number of academic ODLs. In addition to the information available online, interviewing the manager of an ODL hosted by a Computing Department and another hosted by a Department of Art and comparing the results to the professional ODLs provided a positive step forward.

Language was another limitation for both the researchers and many of participants, who are not English native speakers.

Funding was also a limitation of this study. The financial help for conducting this research was limited.

Implications and Recommendations for Future Research

This thesis is a first contribution of evidence about the ecosystem of the ODL community movement. This study discloses a range of topics which are not covered by this thesis, either because of the limitations previously mentioned, or the focus of the analysis. Future research needs to include:

– Test the framework we presented in section V.

– The findings of the thesis showed a standby situation of the ODLs. Conduct a study focused on a diagnosis of the community, seeking for its sustainability and future plans.

– Because of the diversity of ODLs, conduct new single-case studies based on the Tralee case founded categories.

– Explore Web community conferences networking and its relation to knowledge diffusion.

– Environmental issues, and the return and recycling of devices, is a topic mentioned in some blog posts and also in the interviews conducted, but not yet explored.

– The ODL case brings up valuable open principles which give rise to collaborative practices. Even though a case study works with *petite generalisation*, we found similar characteristics, when comparing them to LSCI such as Fab Labs and Living Labs, which might be explored in a systematic way in future research.

Conclusions

Conclusions

This PhD thesis, submitted as a collection of published papers, aimed to explore, describe, and explain the Open Device Lab community ecosystem and ultimately proposed a framework as a result of all the data analyses.

The literature review contributed to the systematisation of work on mobile software testing and evaluation on real devices. The diversity of the data collection from documents, interviews, direct observations, participant observations, and fieldwork notes through an inductive data analysis allowed us to initially understand the complexity of a single case. The thesis findings revealed the main characteristics, practices, benefits, and challenges of the ODLs. These findings showed a grass-roots community movement strongly characterised by a glocally networked community movement, combining local activities and global connectivity (Wellman & Hampton, 1999). The results showed the importance of the network built in-person at Web conferences (Isbister & Mueller, 2015). In addition, the results unveiled the main actors' openness principles as a key aspect to give rise to sharing practices and to engage (Rosen, 2007) in a new grass-roots movement to help local communities to improve the Web and app user experience for both developers and end-users.

The results helped to understand a contemporary phenomenon, hitherto unexplored, a revealing case. This dissertation offered theoretical contributions and defined concepts for the ODL literature. In addition, this thesis contributed to the mobile software testing and evaluation field, open labs networks. Lastly, this PhD thesis explored how the ODL community works and proposed a framework for establishing academic ODLs.

We concluded that the most important concepts of the ODL community movement are its **openness**, **sharing**, and **collaborative principles**. We considered this case to be an example of a movement led by **Web development actors and grounded in the Web design principles, Web for all, and Web on Everything** (W3C, 2017b). The mobile industry is a growing market as well as the testing and evaluation field, and the

contribution of this thesis will be valuable not only to the ODL community but also to the mobile academic and industry community.

The main findings of this thesis were as follows:

- The ODL ecosystem is strongly characterised by local activities and global connectivity grounded in the principles of openness, sharing, and collaboration.
- Their focus is Web and app quality assurance aligned to the Web standard design principles.
- ODLs have common elements but multiple different implementations offering small-scale services for in-person testing and evaluation.
- Their approach tries to democratise testing and evaluation on real devices to lead to the ultimate improvement of the Web and app experience for both developers and consumers.
- The most straightforward laboratories are shared ODLs; for any other case, there is not yet a solution.
- Online user reviews are a key strategy for the long-term local and global management of the ODLs.
- ODLs offer a high potential to serve Web and mobile game lab-based testing and evaluation for indie studios.
- A device lab is a resource, and an ODL is a voluntary free service.
- Academic ODLs aim primarily to support teaching and learning practices related to higher education disciplines, and an ODL might be a space to experiment, learn, evaluate and test, collaborate, and connect the academia and the industry.
- Both the global community and many labs appear to be in a standby situation. A solution for maintaining the community principles and sustainability would be to implement a non-profit business concept of seeking income to sustain the mission. Although, this is still a hypothesis.
- A key concept to understanding the ODL community movement is to understand the Open Web ethos.

Contributions

Academic and professional achievements during the thesis.

Journal publications

Godinho-Paiva, Raquel; Contreras-Espinosa, Ruth. S. (2019). Online User Reviews as a Design-Strategy for Global Communities: Contributions of the Open Device Labs Case. International Journal of Interactive Mobile Technologies (iJim). Volume 13. Number 11. November. 10.3991/ijim.v13i11.11042

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Godinho-Paiva, Raquel; Contreras-Espinosa, Ruth. S.; Horgan, Claire (2019). A responsive Web design evaluation methodology – considerations on an experience of classroom and laboratory integration on higher education at IT Tralee. 13th annual International Technology, Education and Development Conference - *INTED 2019.*

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Conferences posters

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Godinho-Paiva, R. y Contreras-Espinosa, R. S. (2015). Open Device Lab: movement to improve Web and app experience. *Poster presented at the 5th International Workshop on Higher Education*, Vic, Spain.

Other academic activities

PhD Eramus+ traineeship

April-June 2018

Institute of Technology of Tralee, Tralee, Ireland.

UVic-UCC

Scholarship, Doctoriales Transfrontalieres

March 2017

Cross Borders at University of Perpignan, France.

UVic-UCC

PhD Erasmus+ traineeship

October 2016 – January 2017

University of Eastern Finland, Joensuu, Finland.

BBVA i Manlleu and UVic-UCC

Research Fellowship

May 2016

LabUp! Berlin, Germany.

UVic-UCC

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Appendices

Appendix I: ODL UVic

ODL UVic was part of the participant observation data collection. We decided to carry it out as a side project just like the labs we knew. We have been trying to set up the ODL UVic since 2016. Because of the challenges faced at the University, related to authorizations and protocols, we only asked for registration in the ODL community directory on 11 July 2018 as 'our ODL has not been established yet'.

After significant advances in terms of support, we changed our register to 'Our ODL is established and starting up', and on 29 April 2019, ODL UVic was published in the community directory.

ID: 3139

Name: Open Device Lab UVic

Donations: Accepts device donations

Description: The Open Device Lab of the University of Vic - Central Catalonia offers the use of real devices for the purposes of testing, designing, and developing websites, applications, and games. The lab is open to the internal and external community free of charge. The ODL is located at the library of the Faculty of Science and Technology.
City: Vic

Country: Spain

Organization: Universitat de Vic - Universitat Central de Catalunya

State: Catalonia

Address: 13 Laura Street

Zip code: 08500

Number of devices: 17

Status: just_established

Type: resident

URL: https://mon.uvic.cat/ust/en/recerca/open-device-lab-odl

E-mail: odl@uvic.cat

Twitter: @odlUVic

Pinterest: https://br.pinterest.com/raquelifsul/odl-open-device-labs/

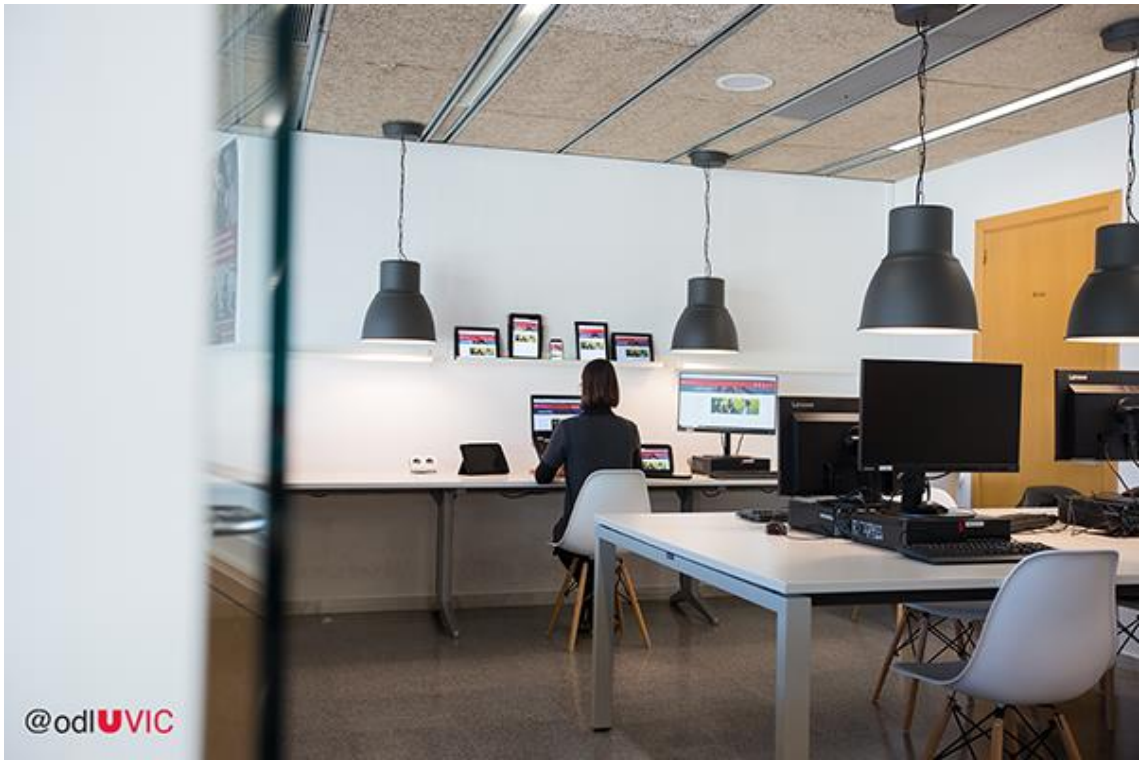

Figure 12 ODL UVic

Source: author

Appendix II: Interview Transcription Template

Interview transcription template

Remember: This material is confidential. Please do not make copies or share it.

Recommendations:

- Always ODL or Open Device Lab (not odl or open device lab)
- [inaudible audio]
- ?(text)? When there is doubt on what was said
- He/she said: 'text' (for quotations)
- Yeah, Hum, Mm-hmm (affirmative)
- * text * marks for anonymous information such as names.
- Okay or OK.
- (short laugh)
- (sight)
- … for short pause or incomplete sentences
- [pause] for long pauses
- Text- for interruptions

Interview: 0000X (e.g. 0004H - H for History, E for exploratory, and N for non-ODLs)

Participant: nº (Name) erase 'Name' in the anonymous file.

Interview Location:	Country
Cadre:	Job Role – ODL role
Date:	Day Month Year
Number of Attendees:	[n]
Name of Transcriptionist:	Name
Interview Duration:	00:00:00

[00:00:00]

C- Code (if is the case)

Interviewer- *question.*

Participant X- answer.

Appendix III: Glossary

Participant-observation - when the researcher becomes involved and becomes part of the community or environment where the study is developed.

Game metrics - the term generally refers to the process of logging player interactions, camera angles, positions in the game and all data that relates to the gameplay interaction.

Indie studios - refers to those games typically created by individuals or smaller development teams.

Interaction design - is the design of interactive products and services in which a designer's focus goes beyond the item in development to include the way users will interact with it.

Human-computer interaction (HCI) - is a multidisciplinary field of study focusing on the design of computer technology and, in particular, the interaction between humans (the users) and computers.

Service Design - is all about taking a service and making it meet the user's and customer's needs for that service.

Customer journey/user mapping - is a process that provides a holistic view of the customer experience.

Service Blueprint – is a diagram that visualizes the relationships between different service components (people, props, and processes) that are directly tied to the touchpoints throughout the customer's journey.

Minimum Viable Product (MVP) - a development technique in which a new product or website is developed with sufficient features to satisfy early adopters.

Softwrare Quality assurance (SQA) - is a set of activities that define and assess the adequacy of software processes to provide evidence that establishes confidence that the software processes are appropriate and produce software products of suitable quality for their intended purposes.

Appendix IV: Researcher's Resume

Raquel Paiva Godinho is a tenured lecturer and researcher at the Design Department of the Federal Institute of Education, Science and Technology Sul-rio-grandense (IFSul), Brazil. Currently, she is a member of the Balmes Foundation team involved in a H2020 project, and a PhD candidate in Experimental Sciences and Technology at the University of Vic-Central University of Catalonia (UVic-UCC), Spain. Her current research interests include design and collaborative practices.

EDUCATION

University of Vic-Central University of Catalonia, Vic, Spain

Doctoral student in Experimental Science and Technology 2015-present

Federal University of Rio Grande do Sul (UFRGS), Brazil

Master of Science in Information and Communication 2008-2010

Catholic University of Pelotas (UCPEL), Pelotas, Brazil

Specialization in Communication Science 2007-2008

University of Vale do Rio dos Sinos (UNISINOS), Brazil

Specialization in Graphical Design 2004-2005

Federal University of Rio Grande (FURG), Rio Grande, Brazil

B.A in Visual Arts 2000-2004

Federal Centre of Education and Technology (CEFET), Brazil

Certificate in Industrial Design 2000-2002

AWARDS, FELLOWSHIPS, AND GRANTS

PhD Erasmus+ traineeship grant

Institute of Technology of Tralee, Tralee, Ireland.

UVic-UCC 04-06/2018

Scholarship, Doctoriales Transfrontalieres

Cross Borders at University of Perpignan, France.

UVic-UCC 03/2017

PhD Erasmus+ traineeship grant

University of Eastern Finland, Joensuu, Finland.

BBVA i Manlleu and UVic-UCC 10/2016-01/2017

Research scholarship, LabUp! Berlin, Germany.

UVic-UCC 05/2016

VOLUNTEERING

MOBILE HCI – Barcelona 2018

Smashingconf - Barcelona 2017

Beyond Tellerrand - Düsseldorf 2016

TEACHING EXPERIENCE

Tenured Lecturer and researcher – Design Department 2009- present

Federal Institution of Education, Science and Technology Sul-rio-grandense (IFsul), Pelotas, Brazil.

Lecturer – Systems for Internet Bachelor degree 2008 - 2009

Anhanguera Faculty, Rio Grande, Brazil

Module – Web design

Lecturer – Systems for Internet Bachelor degree 2007 - 2008

Atlântico Sul Faculty, Rio Grande, Brazil

Module – visual design

RELATED EXPERIENCE

Art Finisher - Graphic and Digital Designer 2006-2007

WOW! Advertising, WOW, Caxias do Sul, Brazil

Graphic Designer 2002-2006

Conexão Marítima Comércio Exterior Ltda., Rio Grande, Brazil.

OTHER PUBLICATIONS AND PAPERS

Brisolara, Daniela; Godinho, Raquel P.; Mendonça, Fabiana. M.; Rocha, Angélica. L. (2014) Design e lugares de memória no espaço urbano: estudo exploratório sobre a paisagem tipográfica de Pelotas In: Seminário Internacional em Memória e Patrimônio, 2014, Pelotas. Anais do VIII Seminário Internaiconal de Memória e Patrimônio, 05 a 07 de novembro de 2014.

Godinho, Raquel Paiva. (2011) HOTSITE - um formato da publicidade online no Brasil In: CIPED VI - Congresso Internacional de Pesquisa em Design, 2011, Lisboa. CIPED VI.

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CONFERENCES AND TALKS

Che_la per la Ciencia. Me prestas tu móvil? Comunidades abiertas de evaluación y testeo de apps. (2019). Red Global MX. Barcelona, Spain

La Teva Tesi en 4 minuts. El uso de dispositivos reales (Open Device Lab) en el desarrollo de proyectos académicos en tecnologia móvil. Vic, Spain.

INTED 2019. A Responsive Web Design Evaluation Methodology: considerations on an experience of classroom and laboratory integration on higher education at IT Tralee. Valencia, Spain.

The Research in the Faculty of Sciences and Technology of the UVic-UCC. The PhD students. Doctoral Conference. The use of real devices (Open Device Lab) for the development of digital interfaces. (2017) University of Vic. Vic, Spain.

edTech & interactive technologies research seminar. (2017) Open lab field studies and theoretical work. University of Eastern Finland. Joensuu, Finland.

UTU/IxD seminar. (2016) Open Device Lab Community. University of Turku, Finland.

edTech & interactive technologies research seminar. (2016) Open Device Lab Community. University of Eastern Finland. Joensuu, Finland.

VS-Games (2016) – Barcelona, Spain

Testing games on real devices. (2016) Games4everything. University of Vic. Vic, Spain

LANGUAGES

Portuguese – native language

English – speak, read, understand, and write with C1/C2 competence

Spanish – speak, read, understand, and write with C1 competence

Catalan – read, and understand with A1/A2 competence

MEMBERSHIPS

Data and Signal Processing and research group, UVic-UCC, Spain. 2016 - present

Konekto research group – Uvic-UCC, Spain. 2015 - 2016

More information on http://lattes.cnpq.br/7286618996405937

Appendix V: Codebook paper I – User Reviews' Main Codes

ODL RATE	Smartcode CODE: URW - ODL RATE DEFINITION: user review ratings for overall satisfaction from 1 to 5 stars in the online directory. WHEN IT IS USED: when analysing the online user reviews' star rating system. WHEN IT IS NOT USED: when it is not part of the user reviews.	Example '*, Rated 1 of 5' '**, Rated 2 of 5' '••• Rated 3 of 5' '•••• Rated 4 of 5' '••••• Rated 5 of 5'
ODL STATUS	Smartcode CODE: URW - ODL STATUS DEFINITION: ODL status situation: open or closed; and similar to temporarily closed or moving to other office. WHEN IT IS USED: when the information is clearly rating or mentioning the ODL status. WHEN IT IS NOT USED: when the information is not clearly rating or mentioning the ODL status	a. 'ODL open' or 'ODL closed' b. 'they're currently moving offices'
ODL PRACTICES	Smartcode CODE: URW – PRACTICES DEFINITION: user guest comment about the positive and negative experiences with an idea, belief, occurrence, or method, which can be interpreted as a practice related to the ODL ethos to be applied or not WHEN IT IS USED: when it relates to the ODL ethos and can be applied as a good or bad practice WHEN IT IS NOT USED: when it is not related to the ODL ethos and cannot be applied as a good or bad practice	a. 'Informative and friendly without being intrusive into our testing' b. 'we could exchange ideas and point of view on some of our projects' c. 'All were charged, set up, and ready to go!'

TESTING	Smartcode CODE: URW – TESTING DEFINITION: smartcode to group the codes related to testing WHEN IT IS USED: to group codes related to specific testing issues WHEN IT IS NOT USED: when it is not related to testing issues, such as testing experience.	code: testing - backgroundcode: testing - purpose
ODL SERVICE	Smartcode CODE: URW - ODL SERVICE DEFINITION: ODLs service categories WHEN IT IS USED: to comprise the upper-level codes. WHEN IT IS NOT USED: for other codes	code: people code: props
SERVICE PROPS	smartcode CODE: URW – SD - PROPS DEFINITION: related to the prop component of the corresponding service design concept a) physical space - storefront, teller window, or conference room b) digital environment - through which the service is delivered (webpages, blogs, and social media) c) objects and collateral - (digital files and physical products) d) processes - these are any workflows, procedures, or rituals performed by either the employee or the user throughout a service WHEN IT IS USED: when a guest user mentions anything related to props WHEN IT IS NOT USED: when it is not related to props	EXAMPLE: a. ‘Great venue’ b. ‘Excellent resource’ c. ‘Good variation of devices’

SERVICE PROCESSES	smartcode CODE: URW - SD - PROCESSES DEFINITION: related to the processes component of the service design concept. It is related to any workflows, procedures, or rituals performed by either the employee or the user throughout a service WHEN IT IS USED: when the information is related to anything related to the processes WHEN IT IS NOT USED: when it is not related to processes	EXAMPLE: code: URW - ODL S – booking
SERVICE PEOPLE	smartcode CODE: URW - SD - PEOPLE DEFINITION: related to the people component of the service design concept. It is related to anyone who creates, uses, or is indirectly affected by the service (employees, customers, fellow customers encountered throughout the service, and partners) WHEN IT IS USED: when the information is related to people WHEN IT IS NOT USED: when it is not related to people	EXAMPLE: code: URW - ODL TEAM code: URW - ODL GUEST PROFILE
SERVICE BENEFITS	smartcode CODE: URW - SD - BENEFITS DEFINITION: the principal code which represents all the guest user comments about the ODL service benefits WHEN IT IS USED: to group the codes related to the service benefits (props, people, and processes) WHEN IT IS NOT USED: when it is a benefit related to the other codes	EXAMPLE: a. code=URW - ODL B - device collection b. code=URW - ODL B - free service

SERVICE USER EXPERIENCE	smartcode CODE: URW - SD - UX DEFINITION: smartcode to service (SD) user experience codes WHEN IT IS USED: to group the codes related to the service (design) user experience WHEN IT IS NOT USED: when it is not a code related to SD UX	EXAMPLE: a. code: URW - Guest feeling - thankful

Appendix VI: Interview Informed Consent Document

Information for participants

Raquel Paiva Godinho, is carrying out a PhD research study entitled: The use of real devices (Open Device Labs) for the development of digital interfaces.

By conducting a case study research, the project is designed to understand how the Open Device Lab community leads to the improvement of the Web and app experience for their users.

The following research centers participated in the study: University of UVic – Central University of Catalonia, Spain and Federal Institute Sul-rio-grandense, Brazil.

In the context of this research, we request your collaboration to report information about the Open Device lab that you manage and/or work in, as you meet the following inclusion criteria: being or having been a ODL manager, and be or have been involved in some way with an ODL.

This collaboration involves participating in exploratory interviews that should last about one hour. With participants' permission, the principal researcher will videotape and take notes during the interview. The recording is for the purpose of accurately recording the information provided, and will be used for transcription purposes. If the participant chooses not to be on videotape, then notes will be taken instead. If the participants agree to being videotaped but feel uncomfortable at any time during the interview, the interviewer will turn off the recorder on request. Furthermore, in the case that the participants do not wish to continue, then they are able to terminate the interview at any time.

All participants will be assigned a code so that no direct link can be made between the participant and the responses that are given, thus, acting as a guarantee of confidentiality. The data that is obtained during their participation will not be used for any purpose other than that which is explained in this research. All data will be stored safely under the direct responsibility of the principal investigator. In addition to this, the data will be protected by means of **confidentiality**, and only **the principal investigator, the thesis director, and language proofreaders** will have access to it. All participants study data will be handled as confidentially as possible. If the results of the study are published or presented then, names of individuals and other personal identifiable information will not be used unless you give explicit permission for this below on page 2.

Please contact us if you have any questions arising from this information. You can contact us by email: **raquel.paiva@uvic.cat**

Informed consent

I, _____, a person of legal age, with identification number _____, acting in my own name and on my own behalf

STATE THAT:

I have received information about the project ´**The use of real devices (Open Device Lab) for the development of digital interfaces**´ about which I have been given the information sheet attached to this consent form and in which my participation has been requested. I have understood its meaning, my doubts have been clarified, and the actions that are associated with this project have been explained to me. I have been informed of all aspects relating to confidentiality and protection of project participants' data.

My collaboration in the project is totally voluntary and I will not be paid for taking part in this study. I have the right to withdraw from the project at any time, which will revoke this consent. Withdrawal from the project will not have any negative impact on me in any way. If I do choose to withdraw from the project, I will have the right to remove my data from the study files.

As a result of the above,

I GIVE MY CONSENT:

1. To participate in the PhD research, The use of real devices (Open Device Labs) for the development of digital interfaces.
2. To be photographed, and/or audio videotaped.
3. That Raquel Paiva Godinho as the principal researcher can process my data under the terms and scope required for the research.

_____, on ___/___/_____

_____ _____

Participant Principal Investigator

If you agree to allow your name or other identifying information to be included in all final reports, publications, and/or presentations resulting from this research, please sign and date below.

_____ _____

Participant Date

Appendix VII: ODLs' Interview Protocol - General Questions

Interview: CODE

Participant: CODE

Interview Location:	Country
Cadre:	[_____]
Date:	ddth Month Year
Number of Attendees:	nº
Name of Transcriber:	[_____]
Interview duration:	00:00:00

C- About

1. *Could you please introduce yourself and the ODL [name]?*

C- Online - up to date information

2. Is the information on the ODL [name] website and on the community website up to date? [If not, please explain]

C- How/why

3. How and why did you open your own ODL?

C- Legal issues

4. Is the ODL legally registered? If so, how?

C- ODL - maintenance

5. How do you manage the maintenance of the structure and devices?

C- Devices – selection criteria

6. What is the criteria for choosing new devices?

C- Donations

7. Do you accept donations for the lab?

C- Host - testing methodology

8. What is the methodology that your company uses in the lab?

C- ODL protocol - use

9. What are the phases [steps] that visitors [guests] must follow to perform the tests?

C- ODL – infrastructure - laptop

10. Do the guests have to bring their laptop to perform tests?

C- Actors/people

11. Who are the people involved in the ODL?

C- Security - guest

12. How do you manage privacy, licenses and the rights of the projects being tested on the devices?

C- Service cost

13. Is it totally free to use the open device lab?

C- Software

14. Do you offer software for testing? Which ones are they?

C- Guest frequency

15. How often do you usually receive visitors in your open device lab?

C- Help

16. Do you help the guests in some way?

C- Guests profile

17. What is their profile?

C- Service - limitations

18. Are there any kinds of limitations such as devices, software, Internet or other?

C- Unexpected happenings

19. Did you have any unexpected [happenings] after opening the ODL?

C- Host – lab use - frequency

20. How often does your company use the ODL?

C- Devices - loan

21. Is it possible to bring the devices from the lab to somewhere else? e.g. home or my company

C- Native apps

22. How do you test native applications?

C- Testing - kinds

23. What kind of tests does your company perform on real devices?

C- Testing - phases

24. And what kind of projects do you test? Do you perform tests on the starting products, ongoing, finished and/or when they are already on the market?

C- Host principles

25. Do you have other openness or sharing initiatives?

C- Collaborators

26. Do you have collaborators and external supporters or sponsors?

C- Community network

27. Do you have any relationships with other ODLs?

C- Open Labs - network

28. Do you have any relationships with other kinds of labs? For example, Fablabs or Living labs?

C- Academy-industry relationship

29. Do you have any relationships with students, schools or universities?

C- Space activity

30. Is the lab also a space for creation or production or is it just to perform tests?

C- Games

31. Is it possible to test games in the ODL?

C- Community - main advantage

32. What is the main advantage of the community? What is the company interest to join the community?

C- Community - future

33. Do you have any expectations for the future of the community?

C- Something else

34. To finish, would you like to add anything else?

Appendix VIII: ODLs' Interview Protocol - Specific Questions Example

Participant 01 - ODL [name] – manger [name]

Info site ODL - ok/not ok

Website - ok/ not ok

Twitter - date

Facebook - date

Average number of devices X

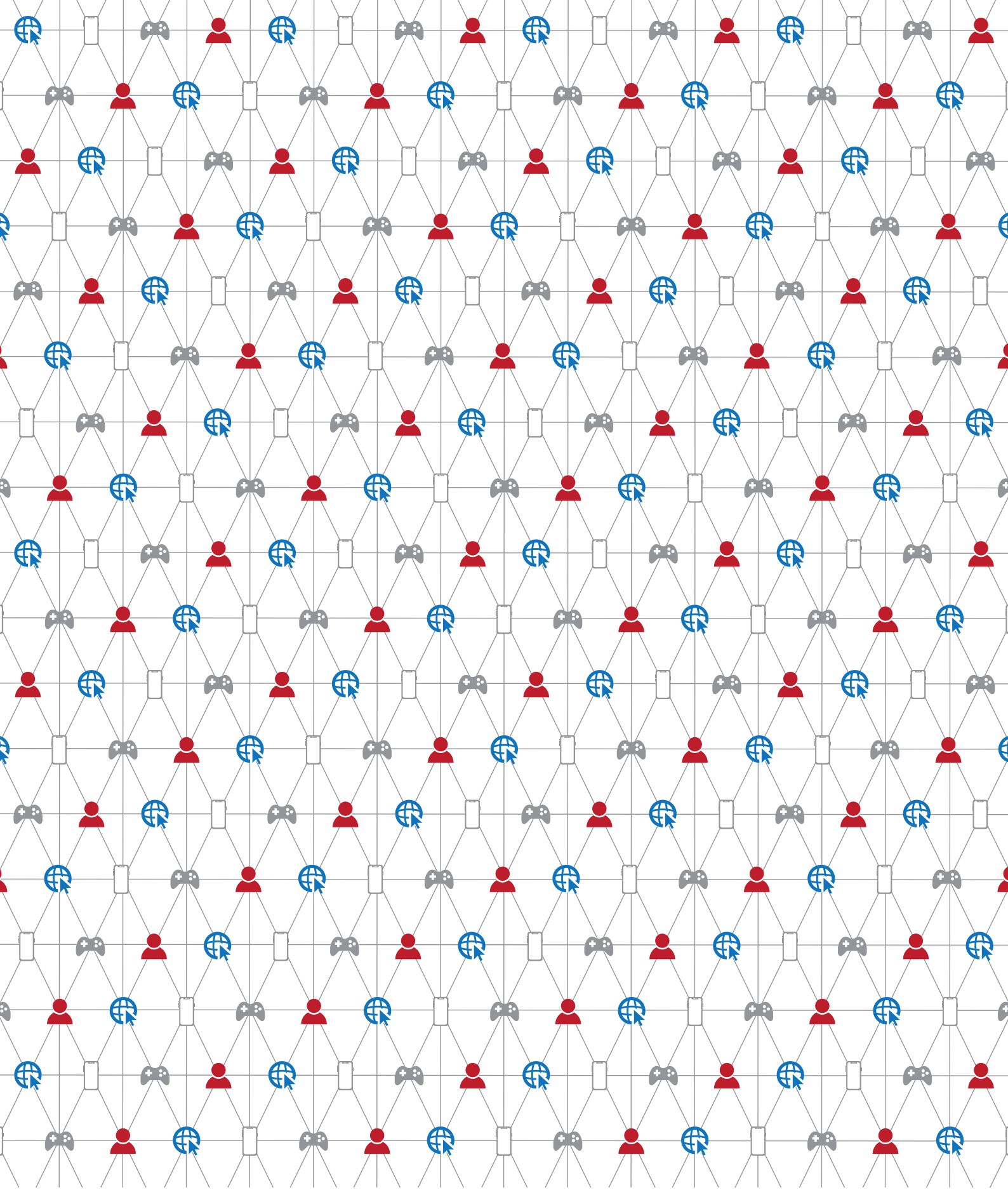
User reviews - X users found the lab open. X stars.

Specificity - A Painel Lego for devices (e.g.)

Software - Name of the available software (e.g.)

Example of questions:

1. I observed that you have important sponsors on the website. How do they contribute to the lab?
2. The ODL is located in the office of [company name], that is also a co-working space. What is the relationship between these three spaces?
3. I observed that the reviews, on the ODL website, are all 5 stars. Additionally, I observed that the reviews are all from 2014/2015. What has happened since that date?



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