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Edited by:
Cristiano Storni
Keelin Leahy
Muireann McMahon
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Design Research Society

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Proceedings of DRS 2018

Catalyst

Volume 3

Editors
Cristiano Storni, Keelin Leahy, Muireann McMahon
Peter Lloyd and Erik Bohemia

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Editorial

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DRS2018, hosted by the University of Limerick and the Limerick Institute of Technology is the first international biennial conference of the Design Research Society since the 50th anniversary conference in Brighton. This represented both a challenge and an opportunity; a challenge to meet the high standards set in 2016, but an opportunity to contribute to a growing design research field. The balance between these has translated into the conference theme of *Catalyst*. A catalyst is something that precipitates events; it is the coming together of different entities to generate something new; it is the spark for wider change. Framed by the Catalyst theme, these proceedings explore existing and emergent areas at the intersections of design research, practice, education and policy.

The conference itself built further on innovations from the past two conferences; developing more interactive conversation and debate formats, and providing a forum for practice-based research through the increasingly popular workshops. A *PhD by Design* day, first initiated at DRS2016, provided a platform for PhD researchers to learn new skills, present their work, and network with other researchers. The design of the conference, however, was largely formed around the managed theme tracks which included themes relating to the Special Interest Groups of the DRS. In some cases theme tracks emerged from conversations held at previous conferences, representing a pleasing continuity.

From the initial calls for participation there was a great deal of interest in the conference. Once again we had a truly international range of work presented and published in these proceedings. The original call for theme tracks yielded 46 proposals from which 24 were selected. These formed the backbone of the conference and of these proceedings. The theme tracks represent an increasing engagement with new technologies and data but also reflect contemporary social and political concerns, and the need for different types of design research voices to be heard. In particular, the programme committee were committed to bringing diverse global perspectives into play during the conference.

Following the call for theme tracks, the call for papers resulted in 470 submissions of which, after a rigorous peer-reviewing process, 218 (46%) were finally accepted for presentation and publication. This is a slightly decrease in the acceptance rate from the previous conference indicating a corresponding increase in the quality of the proceedings papers. Although some papers were submitted to an open call, the majority of papers were submitted to theme tracks, with each track being managed through the peer-review process by a track chair and all peer-review overseen by the Programme Committee. In total nearly 1000 paper reviews were written by 330 reviewers. The opportunity for authors to rate and comment on the reviews they received has further helped drive up the quality of peer review for future conferences.

DRS2018 reflects the coming together of many different perspectives and themes. As with previous conferences its design has been emergent, developing over the two years prior to the conference. It has been the result of many discussions and collaborations both within the Limerick team and the DRS more generally. The conference, and the proceedings that have resulted, are an extensive

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collaboration between many people but we would especially like to thank the local organising committee comprising members from the University of Limerick (UL), The Limerick School of Art and Design (LSAD) at the Limerick Institute of Technology, as well as members of other Irish academic institutions all of whom contributed valuable insight and experience. We'd also like to thank the track chairs who worked tirelessly and diligently to organise their tracks, and the reviewers who have ensured the high quality of the papers within those tracks.

Lastly but not least, we need to acknowledge the system that helped shape the way we worked together and made our decisions: the ConfTool conference management system. For the uninitiated ConfTool represents an awkward and mysterious interface. For the initiated it represents an indispensable way to manage the complexity of every stage of the conference process. In a way that echoes the conference theme, ConfTool has been a catalyst for our collective effort in bringing DRS2018 together.

In this sense *Design as a Catalys*t becomes a *thing*; a thing in the Heideggerian sense of a gathering of different entities coming together to deliberate on shared issues and reaffirming the role of DRS as a leading forum for discussing design research from multiple angles. But also a *thing* in the sense of something that escapes a specific definition, reflecting the impossibility and perhaps undesirability of a specific definition of what design research is, and should be.

With this sentiment in mind, we sincerely hope that these proceedings catalyse positive change and that the changes propagate to DRS2020 and beyond.

Go raibh maith agaibh,

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Developing a Design Toolkit for the Internet of Things

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In a future where products get smarter and networked, becoming part of the Internet of Things, the design discipline acquires an increasingly strategic and visionary role. In the business to consumer market, the successful products will be those that answer meaningfully to user needs. This paper describes the development process of the "MappingTheIoT Toolkit", an open source resource born to support multidisciplinary teams in the design of IoT products. The tools guide through research activities and different phases of the creative process, and can be used freely or in a structured way. This paper will outline the complete Toolkit development: initial research, scope definition, requirements and positioning of the tool in the Double Diamond representation, refinement process and final evolution of the Toolkit elements. The described process may be used as reference for developing other methodological design toolkits. Since the MappingTheIoT Toolkit is in its testing phase, this paper also attempts to get in touch with the scientific community and foster possible collaborations.

design toolkit; internet of things; design methods; product design

1 Introduction

The Internet of Things has received enormous attention. It is seen as an opportunity for organizations to evolve and to elevate their reputation and product offering (IoT WoRKS by HCL Technologies, 2017). The estimated potential economic impact forecasted by the McKinsey Institute (McKinsey Global Institute, 2015) is of $3.9 trillion to $11.1 trillion per year in 2025, for IoT applications in nine settings: home, offices, factories, retail environments, worksites, humans, outside, cities, and vehicles.

In the Business to Consumer market, the first waves of smart connected consumer electronics and wearables are progressively getting mainstream and more widespread (IDC, 2016). Gartner reported that in 2017, consumer applications represented 63% of the total IoT applications in 2017 (Gartner, 2017).

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Although the IoT market is getting flooded by solutions, only few consumer products stand out. (Buntz, 2016). Among them, winning products will be those that succeed in understanding the needs of real users, offering clear value propositions and a coherent service component. In this context, the design discipline acquires an increasingly strategic and visionary role.

For developing meaningful connected devices, it is important to apply what Giaccardi and Fischer define as Metadesign approach (Giaccardi & Fischer, 2008):

> *Metadesign is a unique design approach concerned with opening up solution spaces rather than complete solutions (hence the prefix meta-), and aimed at creating social and technical infrastructures in which new forms of collaborative design can take place.*

This approach was at the basis of "Mapping the IoT", a research project activated at Politecnico di Milano with the aim of developing a methodology to support the product design of IoT products for the consumer market.

The project, originated by an MSc Thesis (Vitali, 2015), started with the selection, analysis and mapping of over 100 case studies of IoT products in the B2C market. As output, we were able to delineate product categories united by formal and conceptual features, and by technological and technical aspects. The data collected was represented infographically (Vitali, 2015) and was later used to design a connected object (Arquilla & Vitali, 2016).

From this case study research became evident that for many of these "smart connected products" the contribution of design discipline was extremely small or absent, especially regarding the whole value proposition and problem framing, rather than in aesthetics.

This lack of design discipline demonstrates that even at a time characterized by the democratization of design tools (Van Abel, Evers, Klaassen & Troxler, 2011; Raasch, Herstatt & Balka 2009), and of production methods (Rifkin 2011; Rifkin 2014; Von Hippel 2005) many products do not have a proper cultural and critical reflection upstream, but rather represent attempts that often don't succeed in the market.

In light of these first considerations, and having developed a demonstrator product that was selected, prototyped and exhibited during Milan Design Week 2016 within the project "Next Design Innovation" (Maffei & Bianchini, 2016) it was decided to further develop the MappingTheIoT research.

The specific goal of this second part of the project was to define an open source tool that would allow designers to develop coherent and meaningful products by guiding them through research and analysis (metadesign phase) and subsequently supporting the design process.

2 Steps from a theoretical framework to the "MappingTheIoT Toolkit"

The first step towards a viable tool was to identify a design-oriented Theoretical Framework able to summarize the peculiarities of IoT objects. The Framework covered some important aspects that need to be considered to build up mature and complete technological products. The six selected aspects were users and context, market, technologies, product design and identity, interaction, and user experience.

Designing for the Internet of Things means considering different levels of complexity, in which products are in a relationship with users, with each other and on a wider network. Without an exhaustive design process, it is easy to treat this topic superficially, and eventually develop tech gadgets with little perceived value, especially in the B2C market.

Given this complexity, we identified that both designers and non-designers felt the necessity of guidance during the design process of IoT products. From this need arose the opportunity to create a Toolkit based on the identified theoretical framework.

The steps followed to design the MappingTheIoT Toolkit were:

1. Research on the existing design toolkits and resources regarding the relationship between the design discipline and the Internet of Things;
2. Wider research on design toolkits and card-based toolkits in particular;
3. Definition of vision and mission of the MappingTheIoT Toolkit. Outline of the requirements and positioning of the resource in the double diamond representation;
4. First prototypes of the different elements of the Toolkit;
5. Test and validation of the Toolkit in a co-design session with experts during NordiCHI'16 (Vitali, Arquilla & Rognoli, 2016);
6. Further refinements of the Toolkit, development of the Activity Guides;
7. Test with students;
8. Release of the Open Toolkit on a dedicated website, new tests and involvement of the scientific community for further evolution of the Kit (in progress).

Since the Toolkit is in its testing phase, this paper will mainly focus on the first six phases here listed.

3 Toolkits and resources on IoT and Design

The term "Toolkit" can be applied to many forms of content and information, and identifies a set of tools arranged together in one place. The concept of Toolkit is not new in the design field, but is a consolidated practice that is increasingly common to overcome the lack of knowledge, methodology or of practical tools for different activities (Lockton, 2013).

Wölfel and Merritt (Wölfel & Merritt, 2013), with the aim of sketching out the panorama of card-based design toolkits defined "5 design dimensions" to classify them.
Toolkits can be distinguished for

- Intended use and Scope (e.g. repository, library of patterns, provocation, support for participatory design, methodology);
- Duration and placement in the design process (e.g. divergent production and brainstorming);
- System and methodology (e.g. the method can be used freely, it has a suggested use, or it has specific instructions);
- Customization of the toolkit (e.g. customization is optional, required, absent);
- Formal qualities of the toolkit (e.g. specific features like using images or only text to describe concepts).

The structure and shape of Design Toolkits may vary. There are cards-based Toolkits like IDEO's Method Cards (IDEO, 2013) and Toolkits that combine an online platform with a printable guidebook such as the "Design kit" (Designkit.org) and "The Field Guide for Human Centered Design" (IDEO, 2015). Other common Toolkit shapes are canvases like the Service Design Toolkit (Service Design Toolkit, 2014) or even games and hybrid solutions (for example the "IoT Service Kit", 2016).

Dan Lockton (Lockton, 2013) argues that

> *The toolkit metaphor may have reached design practice through the use of the term in computer science, particularly in HCI and interaction design where toolkits such as GTK+, Qt and jQuery UI comprise collections of graphical user interface `widgets', with the associated code, which can be used by developers to build a variety of applications, often cross-platform. A toolkit in this sense is directly deployable, providing an API (application programming interface) which can be called by applications, compared with interface design pattern libraries [...] which are more akin to collections of `ways to solve' particular common problems.*

In this sense, since the Internet of Things is first a technological evolution, it is only natural that most of the IoT toolkits are building blocks to support the development of the IoT infrastructure. The role of these toolkits is to support the creation of a network and to reduce the entry barriers for testing

and prototyping both hardware (Moussette, 2007) and software (Koster, 2017). Therefore, these resources are not related to the product and service design discipline.

The increasing relevance of the IoT topic and its complexity is leading to the creation of a consolidated bibliography of resources that tackle the subject in an integrated and instructional way, presenting technological aspects alongside design methods (Biron & Follett, 2016; O'Reilly, 2015) and guiding the design process of connected products (McEwen & Cassimally, 2014; Rowland, Goodman, Charlier, Light & Lui, 2015).

Authors have been reflecting for years about the implications of having augmented products in everyday life (Sterling, 2005, Kuniavsky, 2010), and the debate is becoming increasingly less hypothetical and more contextualized (Rose, 2014; Semmelhack, 2013).

Initiatives like the IoT manifesto (Iotmanifesto.org) are directly addressed to the designers that will develop future smart products, making them reflect on the impact of the design profession in shaping the future. The IoT manifesto proposes a set of design guidelines to encourage paying attention to issues like utility, the whole product lifecycle, privacy and security, data ethics and transparency.

Other resources integrate design strategy and economical aspects, for example the IoT Business Model Builder (Bosch IoT Lab, 2015) developed by Bosch IoT Lab, that proposes a 4-step method to define successful IoT business models and identifies the existing design methods and tools that can support this operation. One of them is the "55 Business Model Patterns" (Csik, 2014) and its IoT expansion for "digitally charged products" (Fleisch, Weinberger, Wortmann, 2014) that introduces business models such as "physical premium", "digital add-on", "digital lock-in" and "product as point of sales".

The first resource that refers itself as "IoT Toolkit" and deals with the topic in a broad way is the IoT Toolkit by Postscapes (Postscapes.com). In this case, "Toolkit" means an updated repository of selected online resources to explore the IoT topic autonomously.

Two relevant toolkits directly address the relationship between products, service design and IoT: the IoT Tiles Cards and the IoT Service Kit.

The IoT Tiles Cards (Tilestoolkit.io) are the result of an ongoing research project at the Norwegian University of Science and Technology. The kit consists of 99 cards grouped in six decks. The kit has different roles. It is a participatory resource that can be used with game mechanics to engage users and non-experts in ideation sessions. It has an informative purpose and introduces the basic concepts about design and programming IoT architectures. It can be used as repository or brainstorming support.

Similarly, the IoT Service Kit (IoT Service Kit, 2016) by Futurice is a toolkit configured like a game, with a boardgame layout. It is made up of maps, 3D printed tokens and five kind of cards: Sensors, Interactions, Service Cards, Open APIs, and User Cards. Using the different elements, the aim is to imagine contextualized user journeys that integrate IoT services with both physical and digital touchpoints. The kit has a Creative Commons license and is useful to brainstorm in team sessions involving designers and different stakeholders.

The Method Kit for Product Development (methodkit.com) is another relevant toolkit even though not specifically linked with IoT. The Method Kit decks are repository of knowledge, summarized on illustrated cards. These cards can be used for divergent production (Guilford, 1984) and are designed as unstructured entities, to facilitate discussion and brainstorming with different suggested techniques.

Several Design Toolkits were examined other than those IoT-specific. The three cases that influenced the most the development of the MappingTheIoT Toolkit are "Design with intent"

(Designwithintent.co.uk), “The Art of Game Design: a book of lenses” (Schell, 2008) and the “Service Design Toolkit” (Service Design Toolkit, 2014).

Design with Intent is “*a collection of design patterns for exploring the interactions between design and people’s behavior, across products, services and environments, both digital and physica*l”. Design with intent means “*a design that’s intended to influence or result in certain user behavior*”. It is a card-based kit developed by Dan Lockton during his PhD (Lockton, 2013). The deck is organized in eight “Lenses”. Each card is phrased like a question in order to act as a provocation, and summarizes a good practice pattern to be followed to achieve a result.

The same concept of lenses is used in the guidebook “The Art of Game Design: a book of lenses”. The “lenses” are more than 100 open questions integrated at the end of each chapter of the book. Questions enable reflection on different themes and stimulate lateral thinking on new perspectives.

The last relevant kit is the Service Design Toolkit, an introduction to the methodologies of service design. The set is made up of several templates that can be filled in and printed. Each template is indicated for a different activity, like for example framing personas, creating user journeys, visualizing actors maps. This configuration makes the Service Design Toolkit a valuable resource for workshops and design sessions.

4 A Toolkit to support the Design Process of IoT products: positioning of the MappingTheIoT Toolkit

With the MappingTheIoT research, we observed the need of a specific design toolkit for IoT products, able to support the design process with a focus on the metadesign phase. We defined a broad and ambitious theoretical framework. We analysed the state of the art of existing toolkits and resources. At last, we reflected on MappingTheIoT Toolkit positioning as a resource.

To position the Toolkit we analysed the functions that it should offer during the whole design process. To stress out this aspect we used Double Diamond representation, a model developed at the Design Council (Design Council, 2005) to summarize the phases of any design process: it is a consolidated representation applied to the wider concept of Design Thinking and not only linked to the product design field.

The Double Diamond model is composed by four phases: Discover, Define, Develop, and Deliver.

The first is the Discovery phase, a divergent moment in which designers explore the design problem, search for inspiration, and analyse the user needs and the market. To support the design of IoT devices, in this phase there is the need of guidance for metadesign research activities such as case studies research, user studies, market research. There is the need of structuring the research correctly from a methodological point of view.

Going in the convergent Define phase, there is the need of visualizing and analysing the gathered insights, transforming them into usable knowledge and product specifications, for an exhaustive project brief. In this phase, pattern libraries could support the problem framing, presenting common patterns in the design of IoT products.

After the brief definition the Develop phase can start, a divergent moment in which to brainstorm and to delineate concepts. Here an IoT Toolkit could support divergent production, reinforcing the lateral thinking attitude providing stimuli and design provocations.

The last moment is the convergent Delivery phase, in which ideas are shaped and tested. For this phase, we identified the need of supporting the concept selection, and of having a repository of relevant aspects that need to be designed, in order to validate and deepen concepts in their initial phases.

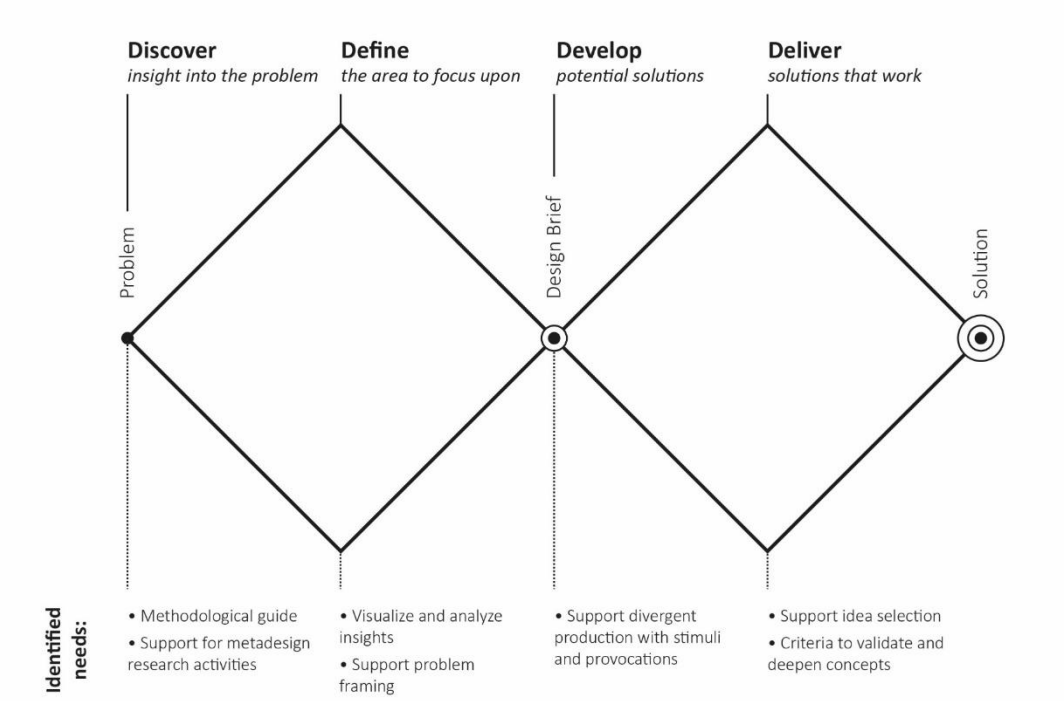

Figure 1. Design needs in the different phases of the Double Diamond model (Design council, 2005)

Having identified a set of activities that the Toolkit could perform in the different moments of the design process, we then delineated the characteristics that the MappingTheIoT Toolkit should have, following the five "Design Dimensions" (Wölfel & Merritt, 2013).

Table 1. Desired characteristics of the MappingTheIoT Toolkit according to the five "Design Dimensions"

Five Design Dimensions	Desired functions
Intended use and scope	Methodological guide, repository of knowledge, support during workshops and design sessions. For designers and non-designers, used alone or within a team. It will not focus on co-design with end-users.
Duration and placement in the design process	Support the design of IoT products, in particular during the metadesign phases and for problem framing activities.
System and methodology	The Toolkit should be flexible. Depending from the activities it should be used freely, with suggested use or specific instructions
Customization of the Toolkit	Customization is optional, but the elements may be expanded and updated with new content. The resource will be published with a Creative Commons license.
Formal qualities	The format of the elements of the toolkits will depend on the function. The card and canvas format will be explored.

5 Testing and Co-Design of the Toolkit

The first version of the MappingTheIoT Toolkit was tested during a co-design workshop at NordiCHI'16 (Vitali, Arquilla & Rognoli, 2016) with a group of professionals in the fields of design, interaction design, technology, and psychology.

The activities of the co-design session were

- Discuss the theoretical framework behind the Toolkit
- Test the structured research exercise provided by the Toolkit

There was a general appreciation towards the framework and structure of the Toolkit. The multidisciplinary panel of experts confirmed the need of having more support during the research phases of the design process, especially non-designers.

The Toolkit components were also tested at Politecnico di Milano with students at their first year of MSc in Design & Engineering. The students, organized in groups with both engineers and designers from different countries, used the Toolkit during their case studies research and for concept definition. The cards were appreciated in an evaluation survey, and the use of the kit demonstrated that a greater awareness led to the development of more coherent and mature products compared to previous years (well defined ideas, technical details of final projects, positive final grades). An interesting point that emerged from both tests was that while non-designers appreciated the structured elements of the Toolkit, designers preferred an unstructured use of the resource, to be kept as repository only when needed.

6 The MappingTheIoT Toolkit

The MappingTheIoT Toolkit (mappingtheiot.polimi.it) is an analogue kit that aims to support designers and multidisciplinary teams in developing successful and meaningful connected products. The kit offers a framework of relevant topics and specific questions. It highlights the key features that smart devices should possess and the aspects that cannot be forgotten while designing for the Internet of Things.

The elements of the kit are usable during different phases of the design process, supporting activities such as research, user studies, benchmarking, brainstorming, interaction design, UX definition, CMF, project evaluation and development.

The MappingTheIoT Toolkit is made up of three elements that can be used freely or for structured activities, alone or with a team. It is licensed under a Creative Commons License and is ready to be downloaded and printed.

The three elements of the Toolkit are:

1. The MappingTheIoT Deck
2. Analysis Cards & Feature Maps
3. The Activity guides

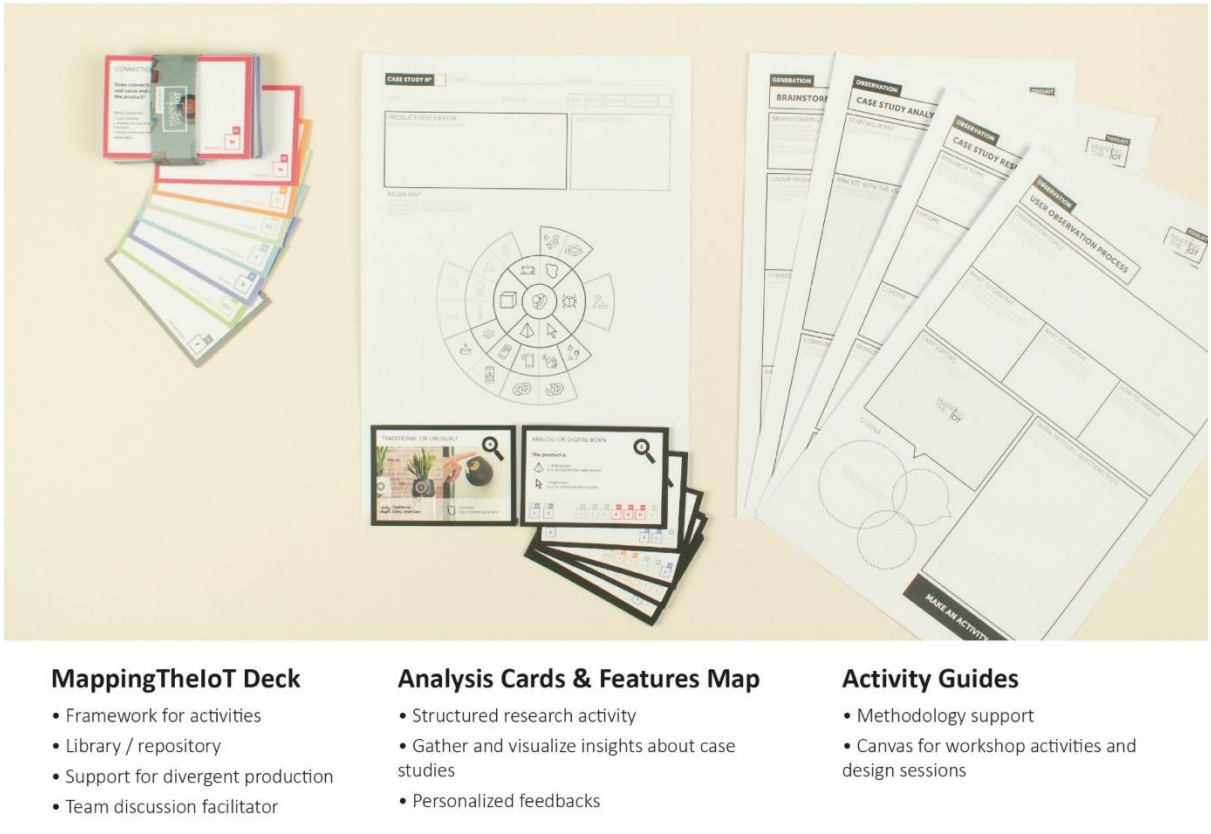

Figure 2. Overview of the Toolkit elements (Version 2.0)

The elements serve different functions and are related with each other. They can be used independently, but reach their true potential when used together. The Toolkit envisions a design methodology in which researching is the first step, followed by an immersive focus on the product. Therefore, the Analysis Cards & Features Map will be used first, and then the Deck. In this paper for storytelling purposes, the Deck will be introduced before the Analysis Cards and Features Map.

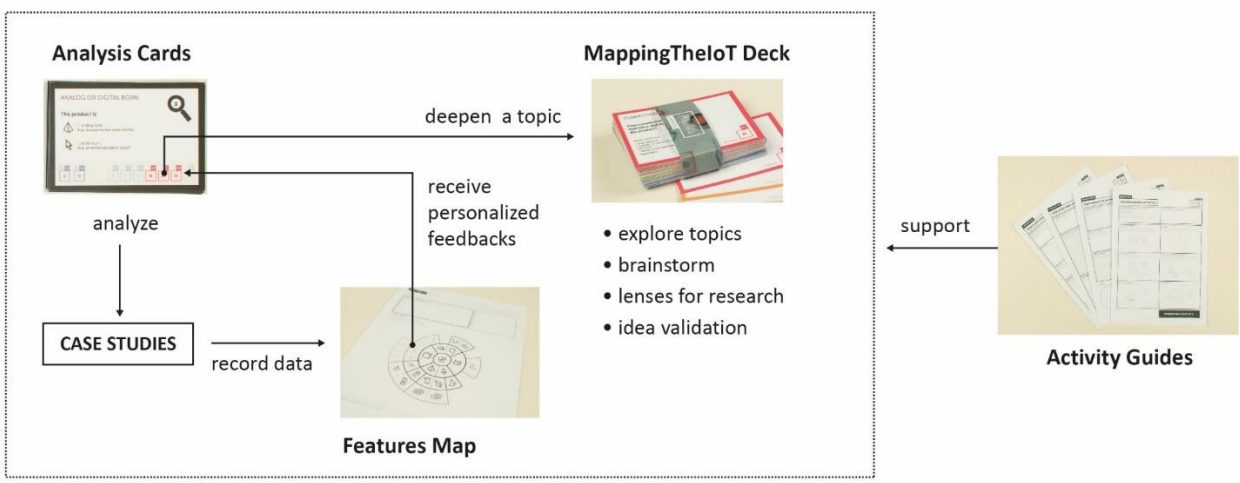

Figure 3. Relationship between the MappingTheIoT Toolkit elements and interaction flow

The three elements of the Toolkit will prove interesting along the whole design process.

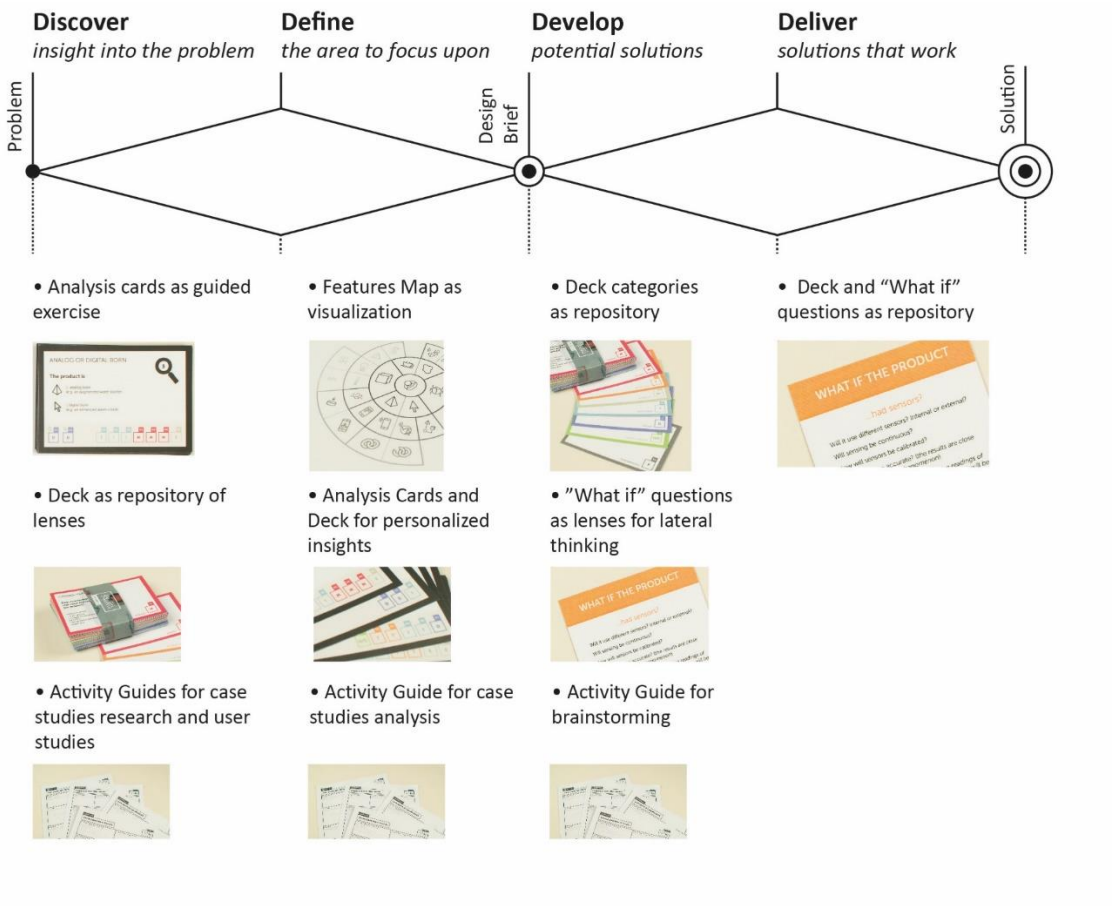

Figure 4. Positioning of the MappingTheIoT Toolkit into the Double Diamond model

7 The MappingTheIoT Deck

The MappingTheIoT Deck is an expandable resource currently made up of 78 two-sided cards organized in seven original categories. Since the Internet of Things is a hot topic of debate, constantly evolving, the Card format was preferred for flexibility, to enable further updates of the tool.

Figure 5. The MappingTheIoT Deck

The front and back of each card are different have a distinct function. The front is read horizontally and introduces a relevant topic through a title and a key question. Its aim is to allow a quick deck exploration for various activities. The back is read vertically and deepens the card topic with specific "What if" open questions, inspired by "The Art of Game Design" lens structure (Schell, 2008).

Both front and back are recognizable by a colour/pattern code and identified by a progressive number in the affiliated category. This to support a structured use of the cards in combination with the other elements of the Toolkit.

The seven categories are User & Context, Design, Technology, Interaction, "Fundamentals", Experience and Material Experience, Meaning. This composition provides a framework for different activities.

Each category represents a key macro area that needs to be strategically designed, a point of view from which to analyse a product. Like for the Six Thinking Hats system (de Bono, 1986) the division in categories lets users experience different perspectives. The "What if" questions are designed to encourage lateral thinking (De Bono, 1990), that as De Bono highlights, differs from the traditional vertical thinking because "Vertical thinking is selective, lateral thinking is generative", it is provocative, can make jumps and isn't sequential. The cards embrace this concept, adding a layer of structure and self-assessment.

The Deck provides elements of reflection that question the cultural value of the design project. It proposes a strategic vision of the process and questions the role of design and designers.

Here follows the description of each category and a general idea of their value and function.

1. **User and Context Cards for framing problems.**
   "User and Context" cards let designers focus on how to better frame problems, needs and opportunities without being superficial. The cards are useful to support the user personas definition, and to explore ideal and extreme user scenarios in which to test new ideas and existing solutions.
2. **Design Cards to design the product**.
   These cards approach the design discipline with a wide angle, providing insights on different aspects of product design, from those related to shape and aesthetics (style, ergonomics, affordances…), design principles (design for all, modularity principles…), and strategic elements (product system, servitization, life cycle). The role of these cards is to aid in the design and strategic definition of the whole product system, with its complexity and constraints. The "what if" side of the cards is particularly useful during the divergent phases of the design process, since it opens up on many suggestions for product development.
3. **Technology Cards exploring the role and potentiality of technology**.
   These cards introduce some of the common features and components IoT products. The approach is not didactic; the cards are not a learning resource or repository of components but are stimuli to deepen the subject. Purpose of this category is to start a reflection on technical aspects, exploring standard and innovative components, features and technology transfer possibilities, keeping in mind the feasibility of the system. Technology cards may be used to identify constraints and opportunities, and as a discussion facilitator for multidisciplinary teams.
4. **Interaction Cards for meaningful interactions.**
   Networked products are phygital entities with a tangible part augmented by a digital avatar (Semmelhack, 2013) but in many smart gadgets tangible interaction is often left out and replaced by apps on smartphones. Interaction cards can be used to balance out tangible and intangible aspects, refining the complete interaction flow with the product. The cards focus on inputs and outputs of the different interaction touchpoints. These cards are especially supportive when designing objects augmented by apps or that need to display, use, and generate data.

5. **“Fundamentals” Cards about market opportunities and business models.**
   These cards represents the “fundamental” information that cannot be missed while analysing any product case study. The cards offer objective questions about the reference market in which the product is positioned, branding and naming details, communication channels, marketing choices, and funding options.
6. **Experience and Material Experience Cards investigating user perception and the role of materials.**
   This section is divided in two to better focus on the different components that contribute in creating a meaningful User Experience. The Experience cards introduce some of relevant topics such as the perception of trust and security. The five Material Experience cards instead guide through a material analysis of existing products. Starting from the Material Description, they focus on the Aesthetic Experience, Meaning Experience, Affective Experience, and Performative Experience that materials elicit in users. The cards were developed on the basis of the Materials Experience framework (Karana, Pedgley & Rognoli, 2014; 2015, Giaccardi & Karana, 2015) and can be used alone as a guided exercise.
7. **Meaning Cards for a Strategic and critical perspective.**
   These cards provide critical questions to evaluate and rate ideas, helping into being more objective and aware of their real value. These lenses add a great value to the Deck, because as Verganti (Verganti, 2017) states talking about the current design scenario in which ideas are overcrowded “Amid this wealth of opportunities, value comes from envisioning which direction makes more sense. It does not require more ideas, but one meaningful vision”.

7.1 Role and functions of the MappingTheIoT Deck

These seven “suits” of cards provide a framework for activities. The MappingTheIoT Deck categories can be explored freely without order, or combined with the other Toolkit elements for structured processes.

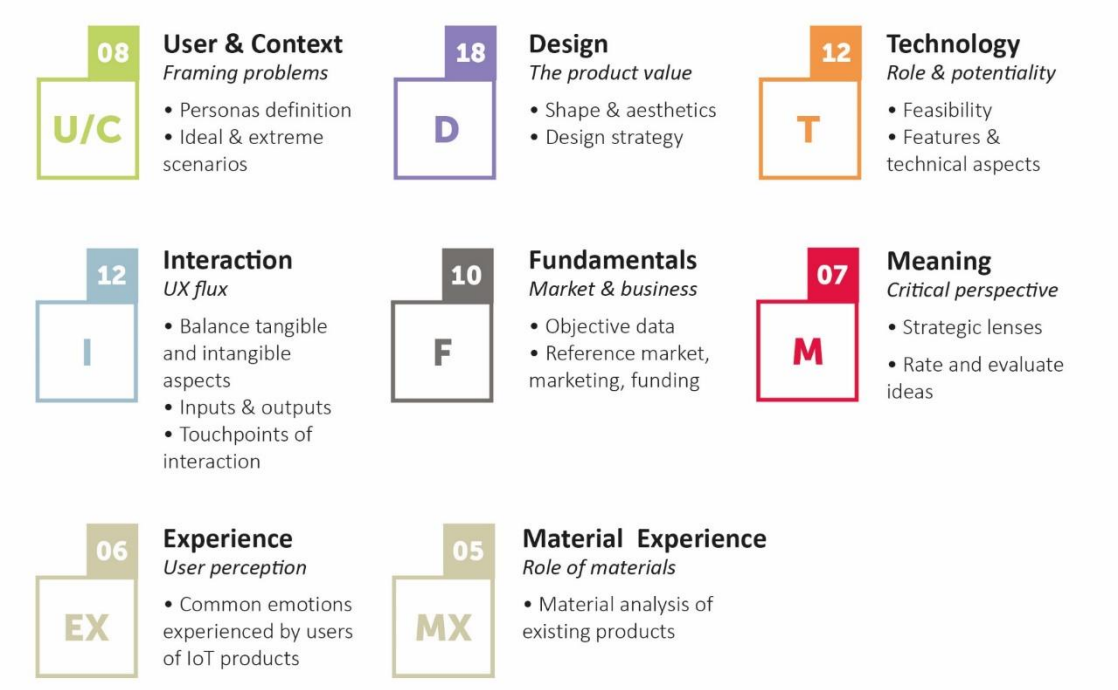

Figure 6. Categories of the MappingTheIoT Deck

In general, the deck is a divergent resource that, with its “What if” questions, encourages confrontation and openness towards new possibilities. Alone, this element is more useful in both the divergent phases of the double diamond representation of the design process. It is a “Library”, a repository of contents, and a facilitator for divergent production and team discussion. In the

Discovery phase, the categories serve as lenses to analyse existing solutions with more awareness. In the Develop phase, the cards can assist brainstorming, idea selection and aid team discussion. In the Deliver phase the “What if” questions can support idea evaluation, testing and self-assessment.

Cards can be used as a provocation, combined randomly to receive unexpected stimuli, used for time-controlled idea generation exercises, addressed by topic to deepen a specific aspect, and used for card sorting exercises to pinpoint relevant themes when working in a team.

The MappingTheIoT Deck can expand with new cards and topics added thanks to professional collaborations and user-generated contents. On the he backside of the cards there is a dedicated space to add new questions, to foster this idea of personalization and evolution of the Deck.

8 Analysis Cards and Features Map

Unlike the MappingTheIoT Deck, the Analysis Cards and Features Map are two elements designed to perform a structured research activity. The two resources will accompany the Toolkit users in a guided meta-design activity: analyse and map case studies to gather useful insights.

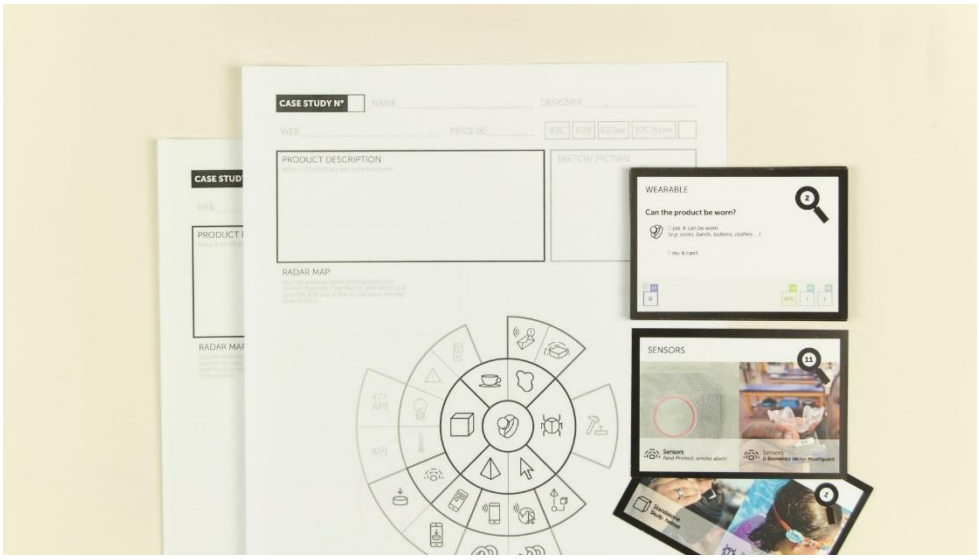

Figure 7. Analysis Cards and Features Map

The Analysis Cards are 15 “black cards”, different from those of the Deck. On the front, there is a simple question with two or fewer possible answers, identified by a logo. On the back, there are two photographic references to explain the logos and better identify the most fitting answer. The same logos are the central element of the Features Map, a canvas-like fillable form.

The Cards and the Map propose a research exercise. Once a relevant case study is selected, the idea is to analyse it by answering the questions proposed by the cards. The Features Map can record the answers and highlight the features that the product possesses. On the Map, there are also dedicated areas in which to write down positive and negative details about the examined case study. This way it is simpler to gather insights and comparable data on each case. By filling one Map for each analysed case study it is easier to spot common aspects and compare them: the Toolkit contains different versions of the Features Map, that guarantee different levels of comparison of the gathered data.

Once users have collected data, the Analysis Cards offer another functionality: on the bottom of the cards, there are specific suggestions that point out to a personalized selection of cards of the MappingTheIoT Deck. It is like a hyperlink. For example the Analysis Card number 2 “Wearable: can the product be worn?” is directly linked to the Design Card number 7 (Wearable shape), to the User and Contest card number 4 (Which are the direct and indirect users of the product?), and to Interaction Cards number 4 and 5 (Time and frequency of interaction. When does it take place? For

how long?). These connections provide an overview of key aspects regarding one given topic, establishing a process of guidance and value creation. In this way, the MappingTheIoT Deck gets more structured, offering not only general stimuli, but also targeted content.

A further evolution of the Toolkit foresees the realization of a digital version of this whole process, with the creation of an online database, able to collect and map case studies suggested by users, implemented with dynamic data visualizations and a system of personalized feedbacks.

8.1 Role and functions of the Analysis Cards & Features Map

This structured exercise finds its position along the first diamond of the Double Diamond representation (Discover & Define phases). It is in the Discover phase because the Analysis cards lead users to perform a structured research. It is in the Define phase because as well as leading users to look for case studies, it tries to give shape and meaning to the collected data, facilitating its interpretation.

Analysis cards and Features map are elements suitable for use during short sessions and workshops with multidisciplinary teams (like hackathons). In general, during this kind of activities, there are strict timetables and many groups tend to start working without properly analysing the topic/brief, nor performing any research activity. By using the 15 Analysis Cards and Features Map is possible to have a quick visualization of the features of case studies.

The analysis exercises proves particularly efficient when analysing case studies with the aim of redesigning the same product, because it gives direct insights and personalized feedback for framing the problem.

9 Activity Guides

The last element of the toolkit are a set of guides that explain how to perform some design activities with the support of all the components of the Toolkit. Therefore, the Activity Guides are an instructional resource to assist Toolkit users into reaching their design goals.

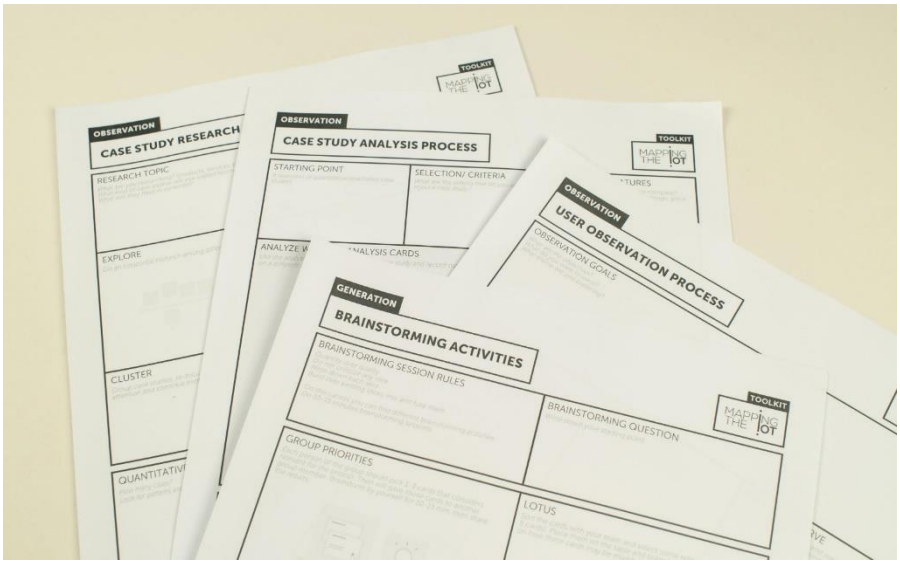

Figure 8. Activity Guides

The Activity Guides were developed following the feedback gathered after the co-design testing of the Toolkit during a workshop held at NordiCHI'16.

From the test emerged that while designers preferred a more unstructured and informal use of the Toolkit elements, non-designers (e.g. professionals within the psychology or tech field) felt the need of receiving more guidance for performing activities. For example, they perceived the Analysis

Cards/ Features Map exercise as clear and with an explicit value, but were uncertain about the usage possibilities of the MappingTheIoT Deck.

The Activity Guides aim to overcome this lack of knowledge about the design methodologies. Their structure is like a walkthrough. They present the different steps to carry out activities autonomously. Currently the Toolkit includes four Activity Guides: “How to plan a user observation”, “How to do a case study research”, “How to analyse case studies”, “Different techniques on how to brainstorm using the MappingTheIoT Deck”.

9.1 Role and functions of the Activity Guides

This element wants to mitigate the knowledge gap that experienced by different members of multidisciplinary teams regarding design methodologies and tools. By using the Activity Guides, the MappingTheIoT Deck become more structured and clear, balancing its high level of flexibility and freedom, which one of the weak points of card-based kits.

The approach of the Activity Guides is instructional, a step-by-step support to the “meta design” phases of problem framing and idea generation. Currently the Guides cover only few activities, but will be expanded in the future.

10 Future steps and conclusions

This paper, besides showing the process for developing a methodological Toolkit for designing IoT products, also attempts to get in touch with the scientific community. Its goal is to open up the discussion about the best practices to design meaningful networked products, and to foster academic collaborations within different departments and universities to test and expand the Toolkit. To underline this the MappingTheIoT Toolkit has been published under a Creative Commons license and is available for free download.

The IoT debate is in continuous evolution. To embrace this attitude the kit offers a methodology based on constant research, that encourage being aware and up-to-date to any technological updates. Its structure is also able to evolve and expand. Its aim is to help spreading a cultural design approach for dealing with products with a technological matrix. This idea of openness is also related to the possibility of personalizing the elements of the Toolkit (e.g. the cards in the Deck) and of receiving suggestions to propose new integrations. In this way the kit will be able to evolve, following future technological scenarios, covering updated issues and topics: for example machine learning and AI in consumer products, the use of chat-bots, the idea of UX bubble.

The Toolkit approach is cultural. It goes beyond the simple generation of IoT solutions, in which the action of mixing an object, a context, an input and an output makes it possible to generate and prototype experimental artefacts. The MappingTheIoT Toolkit has the ambition of making its users, whether designers or not, more aware of the product design possibilities of the IoT. It wants to provide a method that will encourage a culture of research and self-enrichment.

A first possible road envisioned in the future development of the Toolkit is the creation of a digital version, alongside the current one. While tangibility is valuable for some activities, like workshop usage and team discussion, a digital version or a digital Toolkit element may augment some specific functionalities. For example, an online tool could be able to suggest automatically design feedbacks and insights, highlighting recurrent design patterns.

The Toolkit is currently in its testing phase, from design students of Politecnico di Milano, and the current elements will be the starting point for a PHD.

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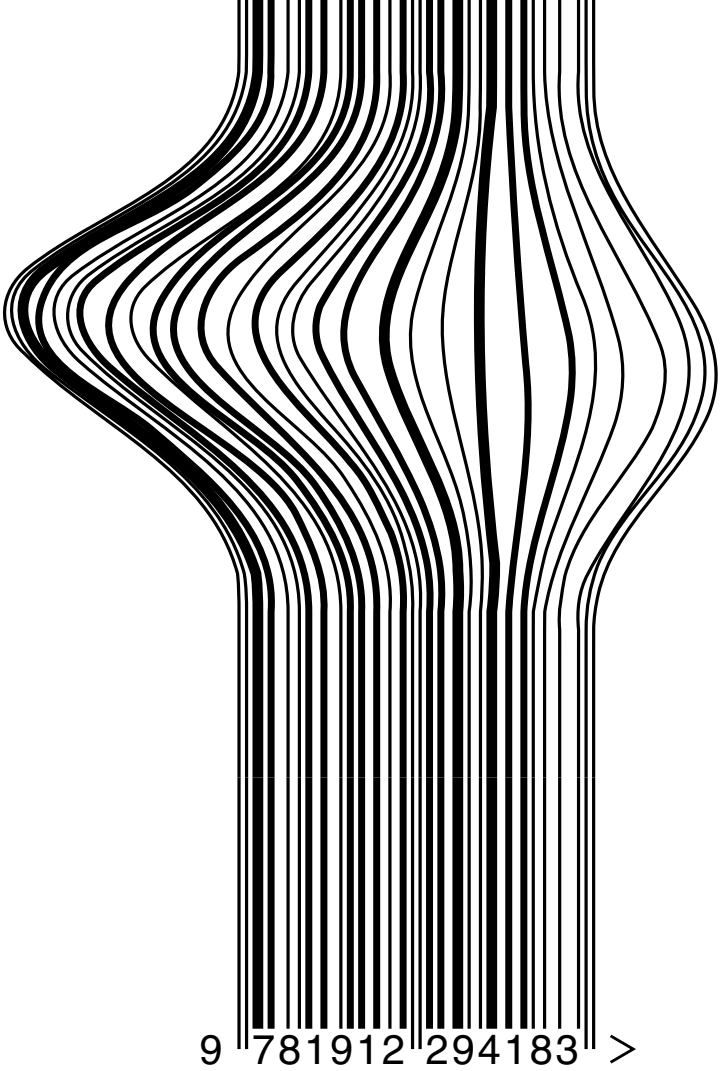

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