P/REFERENCES OF DESIGN

GENERATING DESIGN BRIEFS BASED ON THE ANALYSIS OF WORKPLACE ARTIFACTS INVENTED BY INDUSTRIAL WORKERS: TOWARDS ADDRESSING GAPS OF CONTEXT AND SCOPE IN THE STUDY OF SPONTANEOUS DESIGN.

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DOI: 10.63442/LNYL3431

KEYWORDS | APPROPRIATION, DESIGN RESEARCH METHODS, MANUFACTURING, SPONTANEOUS DESIGN

ABSTRACT | Research on spontaneous design presents a gap of context and a gap of scope. By 'gap of context' we refer to the territory of human workplaces, which are rich in examples of worker inventiveness, but still comparatively unexplored by design research. By 'gap of scope' we refer to how existing studies of spontaneous design have served to document, categorise, and understand design processes made by non-designers, but have fallen short on translating this knowledge into practical advice or tools for professional design practice. We present an initial approach to start addressing those gaps. First, through fieldwork in 11 industrial units in various sectors (textile, ceramics, metallurgy…), we identified and analysed 205 spontaneous design examples made by industrial workers. After analysing these artifacts, we generated design briefs, which were answered by the research team and iterated upon based on feedback from the representatives of the industrial units, as well as industrial workers. To understand whether the principles distilled from the analysis of spontaneous designs could be efficiently communicated to designers not involved in the initial research phase, we presented the same design briefs to design students as well as to design professionals, who presented their design concepts. In total, the process resulted in 15 design concepts. Through an analysis of the process and the resulting design concepts, we discuss the advantages and disadvantages of this approach, while also identifying future courses of action to continue addressing the gaps of context and scope.

1. Introduction

A metallic coat hanger being used as a TV antenna is an example of *spontaneous design*, a term defined by Loschiavo dos Santos (2000, p. 2) as "a creative practice of finding working solutions applicable to solve concrete problems, in a context of severe lack of resources". The term more often than not refers to tangible artifacts which are created by non-designers. A sign of the prevalence of this phenomenon is that it has popular terms in different languages to describe it, such as *gambiarra* (Brazil), *desenrascanço* (Portugal), *klugde* (USA), *jugaad* (India), among others.

Scholarly, the term finds home in the area of 'appropriation' research, which accommodates scholars from design, human-computer interaction, innovation studies and science and technology studies (Kohtala et al., 2020). Scholars working around appropriation are interested in understanding how non-designers create and appropriate products, including digital technology. These actions are also called *adhocism* (Jencks & Silver, 2013), *design-in-use* (Wakkary & Maestri, 2008), amongst others, or just simply *appropriation* (Akrich, 1998).

Understanding the coexisting discourses and terms around the same phenomenon, Kohtala and colleagues (2020) sought to create a unifying taxonomy. This was a significant advancement to unify and advance knowledge in this field. Another recent contribution to the field has been the call for more 'biographies of artifacts and practices' (Hyysalo et al., 2019). The authors suggested that the analysis of design-in-use would be much more informing than current analyses if it would not just focus on the artifact as it is found by the researchers, but also seek to understand its biography through strings of studies. This would allow understanding why the artefact emerged, how it changed, what functions it served in a certain context, or how it relates to how other artefacts evolved. Despite these important contributions to the field, we argue that there is still research needed in order for design to be able to operationalise the knowledge gained from studying this phenomenon. There have been attempts of defining guidelines for design that promotes or supports appropriation (Dix, 2007; Dourish, 2003; Sanders, 2006), but we are lacking research that connects the analysis of spontaneous design examples and converts it into actionable knowledge for design practice. To this we call a 'gap of scope', i.e. so far, the existing knowledge has not found its way into tools and/or information that design practitioners can use.

Furthermore, we also note a gap of context. Research on spontaneous design has mostly focused on 'snap shot' studies (Hyysalo et al., 2019) of certain environments, like domestic (Boufleur, 2013; de Bozzi & Oroza, 2002; Wakkary & Maestri, 2008) or public spaces (Boufleur, 2013; Suri & Ideo, 2005), as well as in certain domains, like healthcare (Storni, 2010) or disability (Hirsch et al., 2000; Jacobson & Pirinen, 2007). Despite signals that blue-collar workers appropriate and create their own tools (Cross, 2012; Juravich, 2017; Narimoto et al., 2020; Zhou et al., 2011; Zuboff, 1989), this is still untapped territory for design research.

However, this context of work is highly relevant for design for different reasons: 1) historically, designers have placed significant efforts in improving working conditions through workplace design (Myerson et al., 2010), which can benefit from methods that help designers understand workers' unmet needs, 2) historically, there have been tensions in the introduction of technology-led change in workplaces (Zuboff, 1989), which can be mediated by designers, and 3) currently, there are growing calls to improve working conditions for blue-collar workers, namely in Europe, where a group of experts has proposed to make Europe the "centre of gravity for good quality jobs", starting with manufacturing and engaging in human-centred design, which requires an understanding of current working conditions, challenges and opportunities (European Commission, Directorate-General for Research and Innovation, Unit G.1 et al., 2023).

Analysing spontaneous design in shopfloors could give us an understanding of how workers appropriate their workplace and this analysis could be used as a proxy to understand unmet needs, i.e., the reasons why workers appropriate tools, and the purposes thereof, can help us understand latent needs, for instance in ergonomics. Additionally, since participatory design with industrial workers is highly

challenging (Ardito et al., 2014), studying spontaneous design examples could provide a complement, or even an alternative, albeit necessarily less rich than direct interaction with workers.

In this paper, we present how we have tried to address the gaps in scope and context which we described above by proposing a design research process that draws from the analysis of spontaneous design examples to inform design briefs. Our concern was not so much on delivering prototypes to address issues on industrial shopfloors, as it was to test a method of generating design briefs based on the study of spontaneous design and ascertain whether they would be actionable by design practitioners. Although some phases of the research happened simultaneously (e.g., phases 6, 7 and 8), for the sake of readability, we present this process in chronological order of events (Figure 1), from fieldwork to assessment of design concepts, finishing with suggestions for future work.

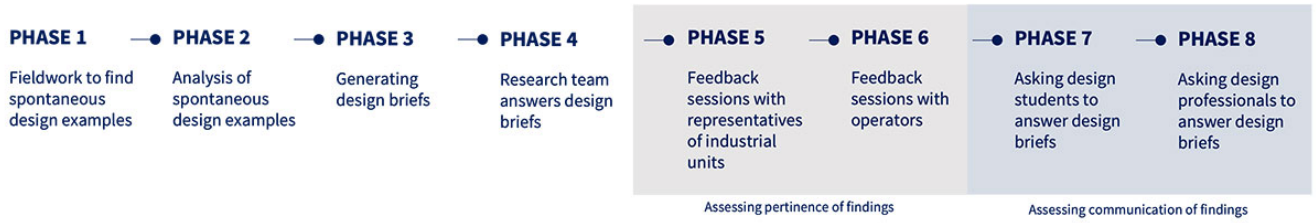

Figure 1. Phases of the research process described in the paper.

2. Building Knowledge from the Analysis of Spontaneous Design

During 2023, we visited eleven industrial units in Portugal working in the sectors of lighting, ceramics, textiles, metallurgy, polymer mould and injection, woodworking and cardboard packaging. During these visits, through factory tours using free non-participant observation and contextual inquiry, we documented examples of appropriation in the workplace by industrial workers. Figure 2 shows seven examples of spontaneous designs we found: A) adaptation to organize tools; B) Protection from machine; C) Tool handle made with tape glue; D) Levers fixed with cork stoppers; E) Tool designed to clean woven wool made from tape glue and rosemary sticks; F) Workbench with secured belongings and personal messages; G) New labels added to machine.

Each example of artifact (205 examples found in total) was catalogued according to Akrich's (1998) four categories of appropriation – *displacement*, *adaptation*, *extension*, *detour* – and analysed for function and underlying motivation for its creation. The photographic dataset of these spontaneous design examples was released in open source (containing the 696 photographs which were authorised by the industrial units for dissemination) (Correia de Barros et al., 2023). Each photograph in the dataset is accompanied by metadata categorising the type of appropriation, the purpose of the object, a description of the object (for alternative reading), the industrial sector, and the country of origin.

The main purposes we found in the sample of spontaneous designs were converted into four design briefs (Figure 3), the requirements of which were also extracted from characteristics of spontaneous designs we found in our research. A fifth brief was added in response to a direct need from one of the industrial units that were visited (Brief #5).

Figure 2. Examples of spontaneous designs found during research.

BRIEF #1

Design a solution to organize and display tools and/or materials on an industrial shopfloor environment.

It should:

- Fit a minimum of 20 tools/materials
- Have a space for each individual tool/material
- Allow the display all tools/materials at once
- Allow to hold tool/material in place if needed
- Allow for easy identification of each tool/material
- Allow labelling with user or sector name
- Provide enough space for approach and use (i.e., to easily remove or place tool/material) from different angles
- Be steady
- Be sturdy

BRIEF #2

Design a way to add information to industrial machinery to reduce errors in interaction and to protect users interacting with the machine.

It should:

- Allow for information augmentation through superimposed layers
- Allow to direct user's attention to certain details
- Allow to mark desired/safe states of machine
- Allow colour coding if needed
- Allow to use text, numbers, icons or bespoke symbols/drawings
- Allow easy removal/replacement

BRIEF #3

Design a way to protect users' hands when interacting with hand tools.

It should:

- Be comfortable
- Be portable
- Enable labelling with user or sector name
- Be adjustable to different hand tools
- Be adjustable to different hand sizes
- Be quick to place and remove
- Allow tool extension for hard-to-reach places

BRIEF #4

Design a way to protect users from particles/objects projected by working machines.

It should:

- Be adjustable in size
- Allow for flexible ways of attachment to different machines
- Be robust
- Allow to be locked in position
- Allow see through
- Allow labelling with user or sector name

BRIEF #5

Design a way for continuous cleansing of conveyor belts.

It should:

- Be adjustable in size
- Allow for flexible ways of attachment to different machines
- Be robust
- Allow to be locked in position
- Allow see through
- Allow labelling with user or sector name

Figure 3. Design briefs.

3. Designing Based on Knowledge from Spontaneous Design

During this phase, the research team worked on design concepts to answer the briefs. Figure 4 shows examples of concepts generated by the research team: A) a modular device for tool organization, which can be combined in groups of four to become table foot elevators; B) a 3D printed flexible and modular element that can be attached to different types of machinery to protect workers; C) a rod system to create storage space underneath workbenches; D) a digital tool to quantify existing material leftovers to encourage reuse and design with those materials; E) a universal tool handle.

While developing the design concepts, we led design feedback sessions with representatives of the industrial units, followed by similar sessions with shopfloor operators. A minimum of three elements from the research team was always present at the sessions. The sessions were not recorded – researchers took handwritten notes, including verbatim transcriptions when deemed relevant, and took photographs of participants' interactions with the prototypes.

Figure 4. Examples of design concepts created by the research team.

3.1 Feedback from Representatives of Industrial Units

We held sessions with nine representatives of eight of the eleven industrial units for feedback on the design concepts. The representatives varied in role, from factory directors to production engineers. The sessions were held in meeting rooms at the industrial units or online, during which the research team presented the designed concepts in paper and in tangible prototypes. During the sessions, the representatives of the industrial units commented on each concept. In the end of the session they were asked to rate the design concepts by highlighting those which they thought had more potential and/or were more useful considering their knowledge of industrial shopfloors.

The representatives of the industrial units validated some concepts, discarded others and offered ideas either to improve the concepts they were presented with or to create new ones. As an example, on the first session, one of the representatives of the industrial units looked at concept B (Figure 4) and imagined it at a different scale, suggesting that, if much larger, this element could be used as a mat for maintenance workers who often need to operate while lying on the floor and, while doing so, would welcome a way to keep their tools, screws and bolts at hand. Surprisingly for the research team, concept A's (Figure 4) secondary function as a table foot elevator was much appreciated by most representatives of the industrial units. What began as an optional function became desired as the primary one. After these feedback sessions we analysed the preferences of our participants, and continued working on the higher-ranked design concepts only: A, B and E (Figure 4).

3.2 Feedback from Shopfloor Operators

We conducted another round of feedback sessions to design concepts A, B and E. This time these sessions were held with operators of five industrial units (11 operators in total) and took place on the industrial units' shopfloors. Again, researchers presented printed images of the concepts and tangible prototypes. Without being asked to do so, most operators began manipulating the prototypes and experimenting them in their workstations and with their tools (Figure 5). This enabled operators to discover drawbacks in the design concepts as well as opportunities for application, for refinement and even new applications.

Regarding concept E, operators gave detailed suggestions on how the mouth of the device should be redesigned to accommodate different tools (e.g., from a metal file to a toothbrush), as well as how the material of the handle should be thought to absorb impact. Operators also found a new use for concept B as a tool organiser, which could be attached to the side of the workbench (Figure 5, second picture from the left) and hold the tools they use more often. Concept A used up horizontal space and this, for the workers, was a negative aspect of the design, since they often need as much free horizontal space as possible to do their work. Their new adaptation of concept B would also avoid frequent opening and closing of the tool drawer, which is what they currently do.

Upon request, the 3D CAD files of the design concepts were shared with the industrial units where these operators worked, so that they could print and use some prototypes there.

The feedback of industrial unit representatives and operators sometimes was similar, for instance, when referring to the need to keep as much clean space on workbenches as possible. However, there were also differences in the possibilities that were anticipated by each group when interacting with the prototypes. This seems to have been influenced by location: while industrial unit representatives were interacting with the prototypes in meeting rooms, operators interacted with the prototypes on the shopfloor and invariably looked around to see possibilities for the objects, and tried them out, which led to the identification of some barriers, but also to some new possibilities for the prototypes to better address their needs.

Figure 5. Photographs from the feedback sessions with operators.

4. Testing Knowledge Translation

As seen so far, the design process conducted by the research team resulted in two design concepts which appealed to operators. In order to understand how other designers not involved in the research and analysis of the spontaneous design examples would respond to the design briefs, we launched a challenge to design students, as well as a challenge to two design professionals who had no prior connection with the research team.

4.1 Design Briefs to Students

Through a partnership with the Polytechnic of Viana do Castelo (IPVC), the research team proposed a design challenge to first year students of the school's MSc in Design. The students were divided into five groups and each group received a different design brief (Figure 3). The students were given no examples of the spontaneous designs found by the research team in order to isolate the effect of having access to that information. Because not all students had visual or conceptual references of industrial shopfloors or machinery, we searched online for images of industrial environments to help students build mood boards with the following terms for each brief: Brief #1: tool organizer in workbenches; Brief #2: buttons in industrial machinery; Brief #3: industrial hand tools; Brief #4: industrial machine protection; Brief #5: cleaning conveyor belts.

Students worked on the design briefs for six weeks. One member of the research team was present at the launch of the challenge, on week four for a first presentation of the groups and feedback, and on week six when students presented the final designs. At the end of the presentation session, the researcher revealed examples of spontaneous designs found during fieldwork and how they were analysed.

Although the students were able to advance on the design concepts, they were concerned that they might be lacking relevant information from the field, since we did not share the fieldwork data with them. The presence of one of our researchers at certain points in the process was reassuring in the sense that students were able to clarify their doubts with a person who, in this case, was a subject matter expert.

Figure 6. Photos of prototypes and drawings made by students to answer the design briefs.

4.2 Design Briefs to Professionals

To understand whether there would be any differences between giving the design briefs to design students or to professionals, we sought to hire design professionals with no prior connection with the research team to answer the briefs. Answering the briefs consisted in delivering a sketch of a design concept. Similarly to Weingarten and colleagues (2020), we tried to recruit individual designers from freelance platforms. We scanned three platforms (Behance, Fiverr and Upwork) for professional services in product design and concept design from any location, who would speak English. We considered that the portfolio quality was generally higher in Behance, and so we decided for that platform. In the project, we had a budget limitation of 500€ per designer, but we understood this was not enough to reach the best-selling professionals, so we sacrificed the sample size and we used a budget of 1.000€ instead. We then took the five design briefs and we used the website random.org to attribute the briefs. We invited two designers to answer the briefs. Having no answer, we invited another two. In the end, only one designer answered and accepted to do the job. This designer got brief #2 (Figure 3).

Seeing that it was difficult to hire independent designers through this platform, and seeing that the sample was drastically reduced, the team agreed to use the remaining budget to try and hire a design studio. This would enable a comparison of approach between an individual assignment and a group assignment. We made a list of design companies operating in Portugal, and randomly selected between a list of three. The first invited company declined and the second accepted the job. This company got brief #1 (Figure 3).

The individual designer and the design company were asked to work on the design briefs independently and were not required to validate their process with the design team. However, as with the students, both felt the need for clarification and validation with the research team. The individual designer prepared a Miro board, which was shared with the research team, with the phases of research, insights/opportunities, and ideation. Throughout the process, the designer asked for comments on the work to help steer the design process. The company delivered a first file with a series of sketches as the design concept evolved, asking for feedback from the research team. The file also contained a section with questions that the company felt lacked answers which would help them improve the adequacy of their design concept to the brief. The company had doubts related to the type of industrial environment they should consider and tools in use at that environment, as well as other questions related to scale (e.g., how many users, how many factory sectors should be considered, what size would be reasonable for the artefact). The company considered that the brief alone was not enough for a good product development process.

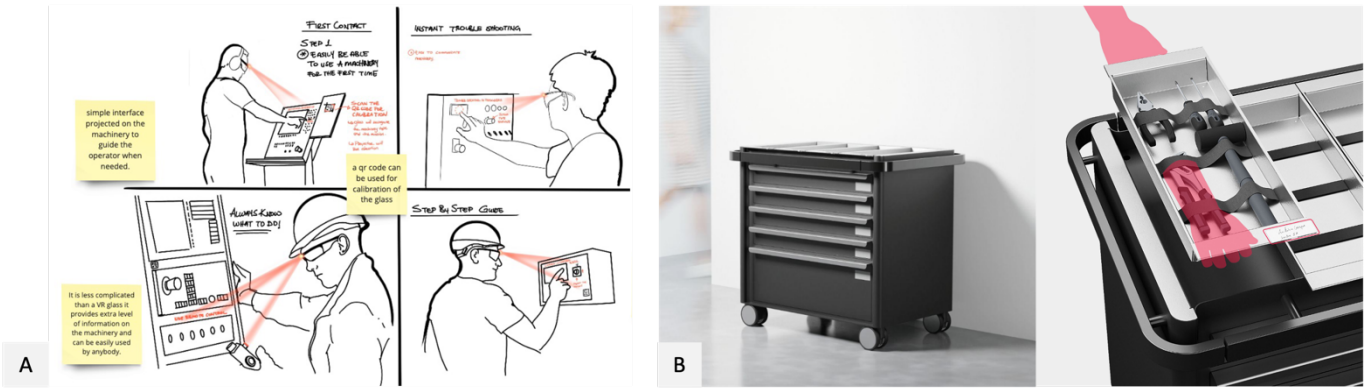

Figure 7. Design concepts by professional designers: A) Glasses answering Brief #2; B) Storage unit answering Brief #1.

5. Discussion, Conclusions and Future Work

As shown by other authors (e.g., Storni, 2010; Wakkary & Maestri, 2008), appropriation in general and spontaneous design in particular not only show in contexts of socioeconomic disadvantage, but in other contexts as well. In the case of this paper, we can also consider the notion of 'lack of resources' forwarded by Loschiavo dos Santos (2000) as time- or effort-bound, i.e., one may be impelled to engage in spontaneous design because one needs to find a working solution with some urgency, or because one does not think that asking others to provide a working solution (e.g., a supervisor on a production line) will be worth the effort. In any case, we have a person who is confronted with a problem to solve and who looks around for available resources to understand how to solve the problem most efficiently in terms of components used, time spent, and how effective the solution will be in answering the problem. In this sense, it becomes clear that the context of work is prone to these kinds of situations and, therefore, to the emergence of spontaneous design. We found multiple examples in single visits to eleven factories in Portugal, thus trying to contribute to closing the gap of context, which is often leaving the realm of work out from spontaneous design research. We hope that this research can contribute to a future 'string of studies' (Hyysalo et al., 2019) which can shed light on how processes of appropriation at work unfold, and how design research and practice can learn from them.

On the other hand, looking at examples shown in Figure 2, they seem to point towards flaws in design. For instance, a machine which requires new labels so that users can operate it denotes a product design process that was not ideal – maybe the original labels came off, maybe they were in a language that users did not understand, maybe there were no original labels, maybe the words in the labels did not have correspondence to users' jargon. There are many possible explanations, but there is an unequivocal sense that the original design did not fully meet its goals. Studying these kinds of artefacts is, therefore, a way of identifying unmet needs, as well as opportunities for better workplace design. Another way in which the research of spontaneous design examples can support design practice is to try to abstract from the concrete examples onto general needs. This is what we tried to do to address the gap of scope. We sought to do it in our research by analysing the functions served by the spontaneous design examples, the way in which they were built, and the motivations that seemed to lay behind the initiative to create the spontaneous design itself. In so doing, we understood, for instance, that often industrial workers engaged in spontaneous design because they wanted to improve ergonomics and safety at work. By analysing which characteristics improve ergonomics for workers compared to pre-existing conditions, we were able to extract general principles. Once we had these general principles, we formulated them as design briefs with which we created experiments among the team, as well as with untrained and trained designers.

Although in some cases the design concepts answering the briefs were similar (for instance, the research team and the students developed similar tool handles for Brief #3), in other cases, the approaches were quite different. For example, to answer Brief #1 (organise and display tools), students and design professionals designed their concepts based on large surfaces which could expose tools, while the research team developed a much smaller object which was designed to hold tools in almost radial format. This difference might have been due to simply different ways of thinking and approaching problems, as it might have been influenced on researchers' side by having witnessed that space is precious on an industrial shopfloor, and so artefacts should minimise the space they occupy. This reflection around space did not come until we saw external designers' concepts and it led us to thinking that maybe this should have been one of the requirements in Brief #1.

We also noted that both design students and design professionals commented that they struggled with not having any other information than the brief. Despite this lack of information, they were still able to answer the briefs and, as noted in the paragraph above, sometimes developing similar design concepts to those of the research team. All external designers knew that the research team was in possession of rich data from the field and would have preferred to have access to it. In our analysis, despite the lack of confidence that this lack of information imposed on design students and practitioners, they were still able to operationalise the principles extracted from the analysis of spontaneous design examples into new design concepts.

As future work, we would like to present these design concepts to representatives of industrial units and industrial workers to get feedback on perceived usefulness. The only significant difference we found between trained and untrained designers in answering the briefs, was that trained designers were better in formulating exactly which further information they would like to have had access to in order to improve the quality of their deliverables. In other words, they seemed more confident in identifying what they did not know.

So far, we have understood that the information we abstracted from the analysis of spontaneous design examples was enough to generate briefs which could be answered by trained and untrained external designers. As future work, we should bring the design concepts generated by students and by design professionals to the workers for feedback to learn about their perceived usefulness. Future work should also address optimal ways of conveying information to designers who were not part of fieldwork, so that design briefs become less generic and more nuanced as to reflect the specificities encountered by researchers in the real-world.

A strength of our research is that it seems to be the first in documenting, categorising and making the examples of spontaneous design available to the design research community. In this sense, although it does not yet allow a vision into biographies of these artifacts (Hyysalo et al., 2019), it can contribute to the strings of studies which can help close the gap of context in the study of spontaneous design. Our research also seems to be the first in seeking to extract design principles from spontaneous design examples to inform design practice. However, the research also has limitations. Reflecting back on the process, we understand that it would have been useful to have collected more structured feedback data to the design briefs from industrial representatives and from operators. We also did not have metrics for design quality with which we could compare work delivered by the research team, the trained designers, and the untrained ones – the fact that we obtained similar design concepts, or not very advanced ones, raises questions about the quality of the design process. This should be investigated further.

Finally, while the research was planned to resort to freelance platforms, following examples from prior research, we were faced with two issues. First, when writing the project research proposal we asked for a budget to hire five professional designers which, by the time we got to this phase of the research was already evidently insufficient – from five planned designers, we could only hire two. Second, the research team reflected about whether, by using freelance platforms, we were supporting design practitioners or rather taking advantage of – or enforcing – a system of precarious working conditions for designers.

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Acknowledgements: This work was conducted with the financial support of the Portuguese Foundation for Science and Technology (FCT), under grant agreement no. 2022.01777.PTDC (Project Craft). The authors would like to thank the support of all the industrial units who generously opened their doors so that we could conduct our research, as well as to all the participants in the research: shopfloor operators, industrial unit representatives, design students, and professional designers.

P/REFERENCES OF DESIGN

This contribution was presented at Cumulus Budapest 2024: P/References of Design conference, hosted by the Moholy-Nagy University of Art and Design Budapest, Hungary between May 15-17, 2024.

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ISBN Volume 1: 978-952-7549-02-5 (PDF)
ISBN Volume 2: 978-952-7549-03-2 (PDF)

DOI Volume 1: https://doi.org/10.63442/IZUP8898
DOI Volume 2: https://doi.org/10.63442/TADX4016

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