# Designing for Design-after-Design in a Museum Installation

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Design-after-design focuses on facilitating the re-purposing and re-design of an artefact by its users. In this article, we explore the challenges of designing for design-after-design through a research-through-design experiment set up in an architecture exhibition for a duration of three months. During those months, we aimed to facilitate the re-purposing of the design artefact by the museum visitors and use that to inform design iterations through which we redesigned the artefact. We gathered in-the-wild data about the novel uses discovered by some of the visitors, but also found that many users were confused by the undetermined nature of the initial artefact. Our research contributes by applying design-after-design in practice and reporting on design implications when developing similar open-ended experiences for museums. Specifically, we discuss implications for balancing openness and constraints in such processes, and suggest further research directions for exploring this challenge.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in interaction design**.

Additional Key Words and Phrases: design-after-design, in-the-wild, museums, play, research-through-design

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## 1 INTRODUCTION

Participatory design projects strive to involve users and stakeholders extensively in their design processes. However, such processes typically end with the final deployment of artefacts. It has been argued that research should explore the ways users engage with artefacts after the design process is finished, at which point the users may re-purpose, redefine or even redesign the artefacts - sometimes referred to as design-after-design Redström [2008]. Design scholars have argued that designers should explore how to extend design processes to incorporate that post-deployment phase [Björgvinsson et al. 2012; Bratteteig et al. 2012; Ehn 2008; Göransdotter 2020; Redström 2017].

In this article, we explore this theme through a research-through-design [Gaver 2012; Redström 2017] process by creating an interactive installation for visitors of the exhibition space of the NN architecture center. Working in-the-wild [Chamberlain and Crabtree 2020] we created *City Lights*, an installation that uses smart bulbs and models to disseminate the role of light in architecture. Following a design process inspired by Redström's design-after-design principles, we design an initial undetermined state for that installation. Through its deployment we aimed to facilitate its re-purposing by the visitors, thus uncovering novel uses that we then incorporated in the artefact, through an iterative re-design process. Building on Davis' theory of affordances [Davis 2020], we explore how this process led us to move from designing an undetermined artefact, towards a gradually more defined design with affordances that encourage certain interactions, while staying open for other types of re-purposing.


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Redström [2008] suggests that the ways in which users appropriate an artefact - potentially redefining its use, or even redesigning it entirely - should be viewed as a part of the design process, coined as *design-after-design*. Design-after-design has been discussed in the context of participatory design [Bjögvinsson et al. 2012; Ehn 2008] and data generation [Feinberg 2017], and has been explored in the domains such as health care [Shidende and Mörtberg 2014] and product design [Ostuzzi et al. 2017]. However, there is a lack of long-term studies on design processes that focus on design-after-design outside of research contexts. This article contributes by applying design-after-design in practice as a structuring principle for a design process taking place over an extensive period of time, allowing us to explore the users' acts of re-purposing through several iterations. This approach allowed us to gain in-depth designerly knowledge about the challenges and benefits of a design-after-design approach, as well as offering some insights to guide further development of design approaches structured around design-after-design and users' re-purposing of artefacts.

## 2 RE-PURPOSING AND PARTICIPATORY DESIGN

Scholars in Human-Computer Interaction (HCI) and interaction design have long been interested in how users re-purpose and appropriate technologies [Benford et al. 2018; Dourish 2003; Gaver 2002]. Henderson and Kyng [1995] introduced the concept of tailorability — which refers to the quality of a system to provide tools so that user can modify (tailor) it post-deployment to fulfill their own individual needs. Both tailorability and the similar concept configurability [Balka and Wagner 2006] refer to qualities of the system, whereas the concept of appropriation refers to the user's action of re-purposing artefacts in novel ways not envisioned by the designer [Dix 2007; Dourish 2003; Salovaara and Tamminen 2009]. Appropriation is also central to understanding ludic experiences [Gaver 2002] since it is a key element of play [Sicart 2014]; a topic that is of increasing interest to designers of museum experiences [Beale 2011; Kidd and Cardiff 2017; Lepouras et al. 2021]. Understanding the role of that re-purposing and incorporating it in the design process has been suggested when museums aim to develop playful experiences [Dancu et al. 2011; Ioannidis et al. 2021] or educational ones [Marty et al. 2013].

Much research in HCI and design has explored the use of participatory design (PD) as a method to create interactive experiences for museum visitors [Bannon et al. 2005; Ciolfi and Bannon 2002; Dindler et al. 2005; Hall and Bannon 2005; Hornecker and Stifter 2006; Rennick-egglestone et al. 2016; Risseeuw et al. 2016; Samis 2001; Simon 2010]. Scholars have also discussed the role that re-purposing and appropriation play in Participatory Design (PD) processes – how users refine, configure, or even re-design artefacts through the discovery of new uses during the post-deployment phase [Bratteteig et al. 2012; Göransdotter 2020]. Redström [2008] introduced the concept of Design-after-Design to describe how users may re-design an artefact through the various ways they decide to use it after it has been deployed – thus "designing" new uses for it. Redström and other design scholars have suggested that in order to support such actions of re-purposing, design approaches that focus on design-after-design should leave an artefact undetermined — or unfinished — in order to let the user define its use (or purpose) through the various ways they decide to use it – in other words, leaving the artefact open for appropriation and re-design through use [Bjögvinsson et al. 2012; Ehn 2008; Redström 2008, 2017]. Binder et al. [2011] suggest meta-design and design as infrastructuring as potential directions for a Participatory Design future which would account for "Design-after-Design". They continue by suggesting infrastructuring strategies. Even though those strategies are relevant when designing infrastructures that relate to artefact ecologies, they operate on a generic level which is not always useful when designing for individual playful artefacts in museums that are not part of a larger ecology. What is highlighted however is that, ultimately, designing for design after design calls for a re-thinking of what should be considered the final products of design processes [Göransdotter 2020].

Empirically, researchers from various fields have explored the implications of design-after-design in various designs and design activities. Working with local health practices in Tanzania, Shidende and Mörtberg [2014] saw design-after-design as a link between the local needs of a user and the needs that the designer predicted regarding a software system in the field of Healthcare. They tried to accommodate for that by "[p]ostponing final design decisions until they are in their use context" [Shidende and Mörtberg 2014, p. 69]. They concluded that studies at the local level of the user can address the challenges designers face regarding connecting design and use. Feinberg [2017] explores a variety of datasets to analyse data generation as a design activity. In her resulting framework, she sees the ways that users collect data as instances of design-after-design, where users become designers of said data, especially in activities which do not support a single interpretation, but rather consist of a variety of different approaches. Following design students during a university course, and studying their co-creation process of assistive devices, Ostuzzi et al. [2017] discuss designing for product adaptations as a form of empowering the user through supporting a design-after-design process that can adapt the product to the optimal solution for the user, what they call "open-ended design solutions" [Ostuzzi et al. 2017, p. 9]. Even though they focused solely on generating instructions during their research, they suggest that further research should focus on transferring those concepts into commercial products rather than instructions. Björgvinsson et al. [2012] have explored design-after-design in practice, by installing Bluetooth technology in public buses to distribute music to its passengers, while at the same time reducing vandalism in the community. Through that a number of different specific projects emerged, via the input of the community. They conclude that designers who employ design-after-design in their process need to consider how to set up such processes so that they can be continuously ready for the changes that come through user appropriation. Developing a digital service related to loneliness and social isolation in rural locations Hayes et al. [2021] discuss how failing to accommodate for design-after-design threatened the sustainability of their design, by assuming a certain future regarding their product which in the end was proven possible after the deployment of the product. Tomej and Xiang [2020] in their study of holiday traveller groups discuss how design-after-design is related to what they call "improvised affordances", affordances that were not designed intentionally and are discovered by the user. All those studies support the notion that users possess an active design engagement role on the deployed product through the various possibilities of re-purposing, which can, then, lead users to innovate or create novel objects and interactions.

## 3 DESIGNING UNDETERMINED OBJECTS

The design of undetermined objects, as suggested by proponents of design-after-design, can be viewed from (at least) two perspectives: undetermined interactions (technological appropriation) and undetermined interpretations (ambiguity). Dix [2007] offers recommendations for designing for undetermined interactions (or appropriation), stating that designers should focus on supporting the user instead of controlling their experience. He suggests that exposing the intentions of the designer and providing visibility to the various functions of the artefact can help the user to adopt and adapt those technologies according to their personal interpretations. Mäkelä and Vellonen [2018] mention that appropriation relates to how designers enable users, specifically through possibilities for self-expression in the designed artefacts. Regarding the design process of such objects, Tchounikine [2017] suggests a life cycle perspective in which (1) an initial artefact with adaptation features is deployed, then (2) the designer performs an analysis of uses that result from user appropriation, and finally (3) the designer re-designs the system to support those novel uses and to help the further discovery of new uses.

The second perspective - undetermined interpretation - emerges from research in the cross-disciplinary area between art and design, where Gaver et al. [2003] have argued that ambiguity may sometimes be a useful resource for design.

An ambiguous artefact can be engaging and thought-provoking, suggesting different perspectives to the user that are connected with their personal experience. Further expanding on these ideas, Sengers and Gaver [2006] argue that designing artefacts that "stay open to interpretation" has a potential to empower users and support them in their individual meaning-making and appropriation of technologies. Exploring complexities of interpretation and ambiguity is central to humanistic research, and thus has also formed an important part of humanistic approaches to HCI [Bardzell and Bardzell 2015] such as artist-based research [Benford and Giannachi 2011] or experience design [Hassenzahl 2010; McCarthy and Wright 2004]. Thus designing for open interpretation has been central to much research in design and HCI that explores aesthetics and museum experiences [Hall and Bannon 2005; Hall et al. 2004; Hornecker and Ciolfi 2019; Ryding et al. 2021; Schiphorst 2009].

However, designing artefacts that are undetermined - both in their possible interactions, and in their interpretation - comes with the risk that the resulting artefacts are harder to understand and use. Constraints, through limiting the set of possible actions, can help users determine possible courses of action in novel situations. Constraints are important in order to teach the user how to interact with an object and what they are able to do [Norman 2013]. They often play an important role in artistic practice, where it has often been discussed how constraints can be used as techniques for stimulating artistic creativity [Elster 2005; Ingimundardottir et al. 2018; Mathews 1997; Mercier 2014]. Such debates have also been brought into the design of participatory experiences for museum contexts, e.g. Simon emphasizes the need for constraints to scaffold participation in meaningful ways [Simon 2010].

Arguably, constraints are of particular importance for the design of games and playful experiences, as pointed out by numerous scholars [Crawford 1984; Juul 2011; Tekinbaş and Zimmerman 2003]. Characteristically, McGonigal quotes the philosopher Bernard Suits' definition of playing games as: "the voluntary attempt to overcome unnecessary obstacles." [McGonigal 2010]. Løvlie [2008] suggests that constraints play a central role when games are used for rhetorical purposes. The balance between constraints and freedom is also central to the distinction between games and play, which is normally seen as an activity that relies less on rules and constraints [Sicart 2014]. Upton describes play as "free movement within a system of constraints" [Upton 2015, p. 15], where players constantly negotiate with the system what is allowed by the (1) external constraints — posed by the system — and (2) internal constraints — posed by the player. He argues that in order to facilitate play, design should aim to give few constraints:

> "In practice, underconstrained systems tend to have more play value than overconstrained ones. When players encounter a system with too few constraints, they often compensate by inventing their own on the fly." [Upton 2015, p. 53]

Given that design-after-design invites users to re-purpose artefacts, a central concern for such processes should be to explore the degree to which the designer should aim to minimize constraints from the outset or whether some constraints are needed in order to scaffold interaction; and if so, how such constraints should be designed, communicated to the user, and how these constraints should be open for negotiation, revision, re-framing or removal by the user when they engage in design-after-design.

The balance between open and constrained interaction can be examined using the concept of affordances, initially introduced in a design context by Norman [2013]. Davis [2020] suggests that we can divide affordances into six categories:

- *request*: artefact requests specific actions from the user.
- *demand*: artefact demands specific actions from the user.
- *encourage*: artefact encourages specific user actions.

- *discourage*: artefact discourages specific user actions.
- *refuse*: artefact refuses specific user actions.
- *allow*: artefact allows specific user actions.

Some of these types of affordances - in particular the *demand* or *refuse* affordances - are rigid, in the sense that they leave little freedom for the user to deviate from the intended action. The other types are more flexible and are oriented towards guiding the interaction, and offer more freedom for the user. Among the **flexible** types, three of them (*request*, *encourage* and *discourage*) provide a specific direction of action, while the fourth type (*allow*) does not. This category describes affordances that are there but the design of the artefact does not directly suggest or oppose actions related to those affordances. Seen in this perspective we theorize that creating an undetermined, open-ended design entails minimizing **rigid** affordances and aiming instead to design for **flexible** affordances. By doing so, we provide the user with opportunities of re-purposing.

In the following we will present our Research through Design exploration of designing for design-after-design in the context of a playful museum installation. Based on insights from the design process and evaluation we will discuss how the users' re-purposing led us to redesign the constraints and affordances of the artefact, and what implications this may offer for designing for design-after-design.

## 4 METHOD

In this study we explore the issues set out above through the design and deployment of an interactive installation for the NN architecture center. We worked in a Research-Through-Design [Gaver 2012; Redström 2017] approach, to gain insights regarding possible design-after-design processes which can support the re-purposing of artefacts through user appropriation. Our purpose was to discover a process which can help us design undetermined playful hybrid artefacts in exhibition spaces.

The first author was employed by the NN architecture center as an industrial PhD student. As part of his employment he designed and developed *City Lights*, the design experiment presented in this article, together with the exhibition and education team of the center. His research position presented an opportunity to conduct the experiment in-the-wild [Chamberlain and Crabtree 2020], gathering data from visitors in the center's exhibition. For re-purposing to emerge, we considered it important that the experiment would be exposed to the regular visitors of the center for an extended period of time, allowing different behaviors to emerge.

Our design process was divided into two main periods: before deploying the installation, and after its deployment. During the first period our aim was to design an undetermined object that would encourage re-purposing. To do so, we incorporated affordances in our artefact which aimed to enhance its ambiguity, and support possible technological appropriations – as discussed in section 3. We theorized that by doing the visitors would discover various new ways of engagement with the installation during the second, post-deployment period. In the second period we observed the visitors' behavior and tried to identify novel ways of engagement. In other words, we wanted to leave it up to the visitors to express, through their actions, what interactions they found engaging. Those observations then guided our re-design of the installation. It should be noted that the educational goals and other aspects of the institution's policies imposed constraints on the possible re-design iterations, both regarding how often we could implement changes and how much we could change each time. However, we argue that even quite small changes in design can lead to interesting changes in the interaction with a game or a playful installation [Altarriba Bertran et al. 2020; Gaver et al. 2004; Juul 2011].

### 4.1 City Lights

*City Lights* was a design experiment set up in the space of NN architecture center from the 3rd of September 2020 until the 8th of December 2020. It was part of an exhibition called "Kids City", which aimed to present urban architecture as seen from the perspective of a child. The exhibition was targeted towards children and families, and many of the exhibits had been designed to be playful and interactive. The project was under development since February 2020, and its deployment was delayed multiple times due to the COVID-19 related lockdown. The purpose of the installation was to allow visitors to explore the effect that different qualities of light have on how we perceive architecture.

*4.1.1 Original Implementation.* For the initial design we aimed to create an interactive installation about light and architecture for an exhibition environment targeted towards families and school groups. Our ideas for the design were developed through discussions with the museum stakeholders in order to align the design with the dissemination values of the institution.

The installation was designed to provide visitors with the building blocks of a small urban tableau, along with a setup of lights that could be manipulated to provide different intensities and colors - allowing visitors to play with different light settings and create different moods on that tableau. The installation (Fig. 1) consisted of a hexagonal table with a collection of small objects and figurines. On the table there were three lamps installed with smart bulbs which could be adjusted using a control interface on an iPad mounted on a stand next to the table. The objects were made from different materials to showcase how light reflects on those materials, an important consideration when it comes to architecture. In order to create an initial undetermined installation, we included a number of abstract shapes as well as some objects that resembled houses, people, plants and other elements of an urban landscape. However the installation did not offer any instructions to visitors, leaving them free to ignore the thematic ideas and instead play freely with the materials and light.

(a) (b)

Fig. 1. *City Lights*

Our initial implementation (Figure 1) of *City Lights* consisted of the following elements:

- a hexagonal table
- three smart bulbs mounted on the table
- an iPad running a web application to control the color and intensity of smart bulbs
- one large metal black house
- one medium 3D printed plastic house
- one small 3D printed plastic house
- ten plexiglass figures of humans, cars, and trees
- eight plastic human architecture models
- a large amount of cubes and spheres of different sizes and materials
- four small plastic chairs and one plastic table

The initial implementation afforded two basic interactions: change the light properties of the smart bulb, and place objects on the table. We intentionally designed the installation to offer as few constraints as possible, and to allow rich opportunities for play and creative expression while giving minimal instructions regarding how to use the installation. We hoped to inspire visitors to explore and play with the installation as they tried to make sense of it, and by that helping us to discover (or design) possible novel uses of *City Lights*.

Furthermore, the installation was designed to facilitate collaboration between several users simultaneously, partly out of consideration for the main target groups of the exhibition - families and school groups - and their presumed interest in socialising and playing together; and partly reflecting research arguing for active visitor participation and interpersonal experiences [Eklund 2020; Hornecker and Ciolfi 2019; Ryding et al. 2021; Simon 2010].

In the initial deployment there were no instructions present in the physical space regarding the installation. However, the control interface on the Ipad included a menu option to open a small '*Introduction*' page that when accessed would reset the color of the smart bulbs to the default (white with maximum intensity) and display the following text:

```
Instructions
1. Choose three objects from the shelves
2. Use the iPad to play with the light and color settings
3. Notice how the mood changes
```

There was also an "About" page displaying the following text:

```
In architecture light and materials create different atmospheres. It
can be a brightly lit city square, a vibrant park, or a dark alley.
Build a small city scene and explore how light, scale, and materials
can create different spatial experiences. You can create your own
experience by placing the objects from the shelves. Then, use the
iPad to control the colour and the light intensity of the three lamps.
```

The main view of the control interface allowed visitors to control the color and intensity of each smart bulb (figure 1).

### 4.2 Evaluation

Our evaluation strategy focused on observing visitors' interactions with the installation and identifying novel uses in order to understand how visitors engaged with the artefact, and which of its aspects were re-purposed. To do so, we

relied on both scheduled and ad-hoc observations, as well as daily surveys of the institution's floor staff, supplemented with conversations with other employees about their observations in the exhibitions.

For the duration of the exhibition, the first author engaged in daily ad-hoc observations of the exhibit to look for specific instances of that re-purposing. Working in an office space on a higher floor with a view down to the exhibition area, he was able to observe when a visitor engaged with the installation, and when that happened he would go down to the exhibition space and observe, as well as documenting the results of the interaction with photographs and note-taking. 73 urban tableaus were photographed during these unscheduled daily observations.

In addition, the first author carried out a series of 15 scheduled hour-long sessions in which he volunteered as floor staff, allowing him to observe visitor interactions continuously and inconspicuously. Whenever interesting behaviors were observed, they would be documented by note-taking and photographs of what the visitors had created. During those scheduled sessions 33 visitors were observed in-depth during their interaction, with their approximate age, group, time spent in the installation, and the specifics of their interaction noted down, along with photographs of what they created.

The center employs floor staff, called "hosts", that are present constantly in the exhibition space during opening hours. Each host fills out a questionnaire at the end of their shift. During the period that *City Lights* was set up, the following sentence was added in the questionnaire form: "Describe in a few words what you observed regarding how the new *City Lights* installation was used by the visitors." That sentence was answered 33 times over the time period that the installation was deployed. In our analysis, we draw from those answers in order to understand in more detail the visitor behavior, since the hosts are present in the exhibition at all times. Through their expertise, the various NN stakeholders – i.e. floor staff, project managers, and department heads – offer valuable insights on evaluating how closely the various re-purposing by visitors and the various re-designs by us align with the institution's goals to educate visitors about architecture.

During the evaluation period the installation went through three iterations driven by the visitors' uses of the installation. For each of those iterations we used the same type of evaluation methods to analyze it.

Unfortunately the COVID-19 pandemic caused some challenges for the evaluation. The pandemic led to periods of low activity in the exhibition space. Furthermore, concerns regarding social distancing policies made it impossible to approach visitors for interviewing.

## 5 POST-DEPLOYMENT RE-PURPOSING AND RE-DESIGN ITERATIONS

Once the installation was deployed, we observed a variety of visitor behavior. The installation was especially popular with groups of children and teenagers, and for many of them the interaction appeared to be intuitive. The ones that engaged with the installation used the physical props to create small tableaus such as that seen in figure 2 (a), which was constructed during the first day of the installation's deployment by a group of 3 children. During their engagement with the installation–which lasted around one minute–they created an elaborate scene incorporating a multitude of objects. Other people focused more on the light and its effect, as indicated by figure 2 (b), a setup left behind by two adults that concentrated on experimenting with different light conditions. Finally, another pattern of behavior that we observed was stacking (figure 2 (c)): visitors spending time stacking objects on top of each other. This was a common and popular activity, especially among families with children and groups of children.

However, many visitors did not spend a lot of time using the installation. Floor hosts told us that many visitors appeared uncertain about how to engage with the installation: "Many do not understand it and move on, especially the children quickly lose interest". Other hosts suggested that the installation was not sufficiently clear regarding its

(a) (b) (c)

Fig. 2. *City Lights* Interactions before re-design

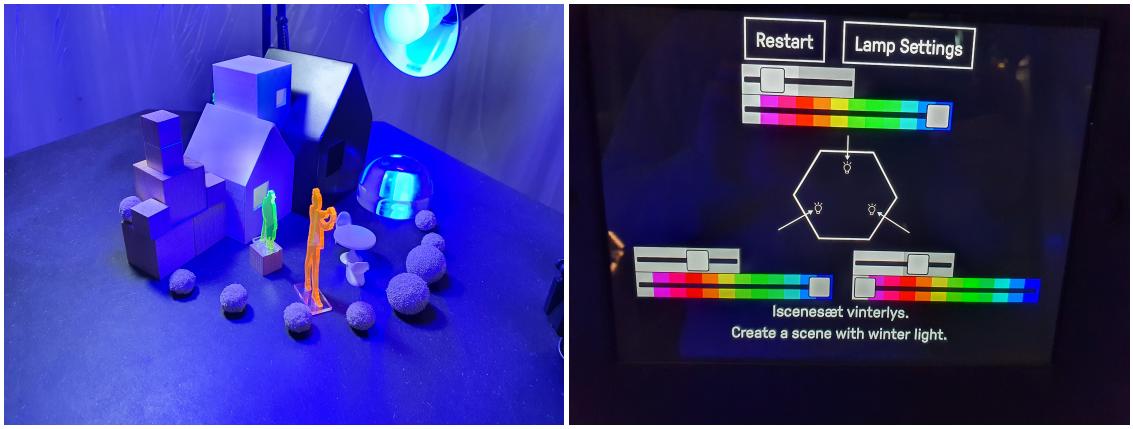
purpose: "Most people seem interested and try out the installation, but they are in doubt about what it will convey" one host noted, with another commenting that "People are confused. They spend more time on Instagram photos than experimenting with the houses and the people". It appeared that the ambiguous and open-ended nature of the installation left visitors confused. However, one of the exhibition hosts told us that he had experimented with presenting the installation to visitors as a game, in order to help visitors make sense of how to engage with it:

> "People like to stand and play with it, but they have to be guided in during the first steps otherwise they do not get the point. In particular, I have succeeded in giving people a small task, for example: 'can you create a cozy atmosphere' 'or can you make it eerie?' to show what light can do to an object."

These observations led to the first re-design of the installation, which was implemented two weeks after the initial deployment (on 18 September) and consisted of two small adjustments: First, in order to offer visitors some initial information as they approached the installation, we put up a physical sign which contained the text from the Introduction and About pages in the control interface (see above). Second, we added an element to the control interface through which the visitor was presented with a challenge, such as "Create a scene with winter light" (Figure 3 (b)), in order to inspire visitors to explore and play with the installation.

These changes turned out to be quite effective, leading visitors to create a variety of designs that were inspired by the prompts, such as that in Figure 3 (a), which was set up by an adult and a child together, spending approximately 10 minutes in the installation responding to the prompt in (Figure 3 (b)). According to a host, visitors seemed to respond with more engagement than before: "I asked some girls who were very preoccupied with it if it worked well and they answered a resounding yes. They used the houses as a kind of dollhouses and put the human figures in there and played family - and then they changed the light". Other hosts offered similar comments, indicating that the changes had made the installation more intuitive and engaging for visitors, in particular due to the prompts. People started to create more elaborate designs, using the collaborative affordances of the installation to experiment and play together. Floor hosts also reported that the suggested challenges initiated interesting conversations between hosts and visitors regarding the properties of light in relation to architecture.

This enabled us to observe more clearly which aspects of the installation the visitors found more engaging and creative. Visitors stacked cubes to create towers (Figure 4 (a)) and other types of buildings, which indicated to us that




(a) (b)

Fig. 3. Urban Tableaus after first re-design

visitors might want to play with more building-like objects. At that moment, the only objects that looked like buildings were the three simple houses seen in Figure ref2 (a). In addition to that, visitors wanted to play with the shadows cast by the light, which was problematic because many of the figures were made of transparent plexiglass and did not cast shadows.

Some visitors also "transgressed" a barrier by mixing elements from *City Lights* with other parts of the exhibition. For instance, one visitor–a toddler–took three of the plexiglass figurines and placed them in another part of the exhibition space on a zebra line (Figure 4 (b)). The physical objects matched the exhibition space–humans walking and a zebra line–and allowed a creative connection of those two exhibition elements. Another visitor left a small robot figure behind on the table, indicating that they had involved the robot in their play with the installation (Figure 4 (c)). These examples demonstrate that the physical props of the installation inspired and enabled the children to easily re-purpose them for their play, allowing them to incorporate the props in their exploration of the wider exhibition space.

Based on those observations, our focus in our second re-design of the installation was to introduce more tangible artefacts of humans and houses. We choose that re-design path, since visitors seemed to engaged more actively – and in more ways – with those models rather than the abstract ones.

The third iteration was deployed a month after the second, on 19 October 2020. The main change at this point was that we introduced eight more 3D printed opaque houses and six 3D printed opaque human figurines. This was done in order to provide more non-abstract objects that represented actual buildings and people, as well as offering opaque objects that could enable visitors to play with their shadows.

Perhaps unsurprisingly, these new props led visitors to play more with the figures - but interestingly, we also observed more families playing together, parents and kids collaborating in stacking and building tableaus. It seemed that visitors now found it easier to make sense of the installation, and we saw an increased engagement from adults as well as kids. It seemed clear that this change towards more specific models rather than abstract opened new possibilities for visitors to express themselves with more creativity and detail (figure 5). More people spent time interacting with the installation, some creating elaborate urban tableaus.

(a) (b) (c)

Fig. 4. Novel interactions

(a) (b)

Fig. 5. Urban Tableaus after second re-design

## 6 DISCUSSION

In this section we will reflect on what insights *City Lights* can offer regarding designing for design-after-design, and present a model of our design process based on our exploration of different types of affordances and constraints.

From the outset we focused on designing an installation which was open and undetermined, both in the sense that there minimal constraints on the types of interactions it afforded, and in the sense that the installation was open to interpretation with little information to reduce the ambiguity of it. However, in spite of our intentions this undetermined state seems to have been an obstacle for engagement. This points to a dilemma for design-after-design approaches: How should one balance between the need to leave the artefact open and undetermined, on the one hand; and on the other hand, the need to design constraints in order to scaffold interactions and help users engage with the artefact?

In order to explore this problem, we turn to Figure 6 which shows a simplified overview of our design process. Our goal was to move from an undetermined design towards an increasingly more engaging one, through iterations of

re-design. A key aspect of our design process was to instil the discovered uses in the artefact through the re-design iterations. In other words, once visitors discovered novel interactions, our goal was to change the artefact in such a way that it would be clearer to future visitors that such interactions were available.

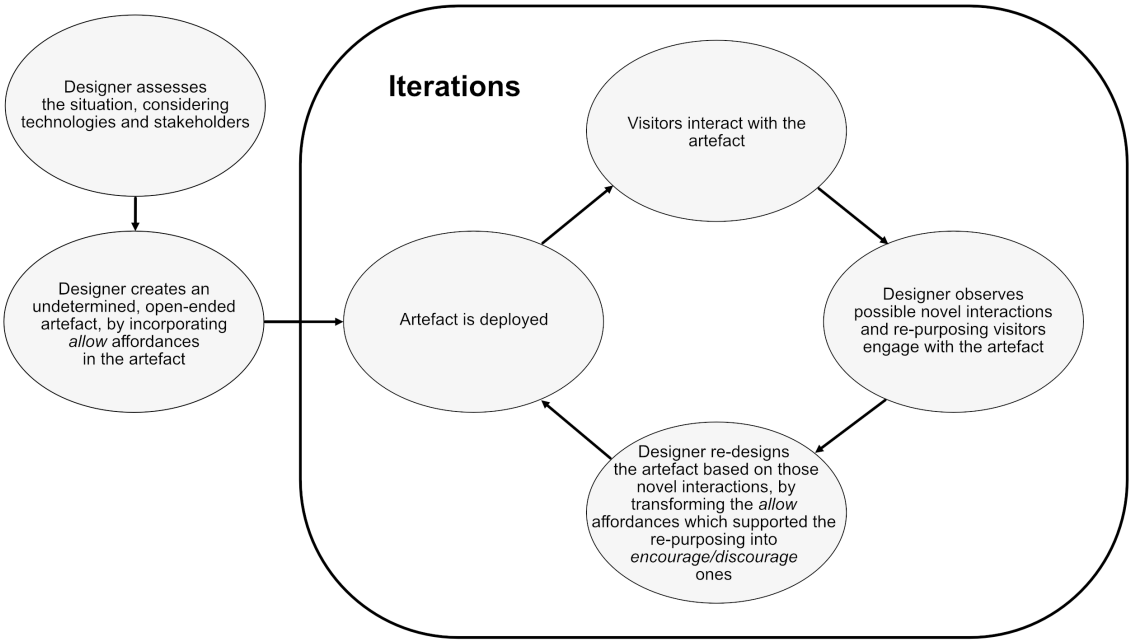



Fig. 6. Our Design Process

To examine this process more closely, we refer back to Davis' theory of affordances [Davis 2020], which we introduced above. The initial version of *City Lights* offered a wide range of *allow* affordances: physical props that could be used freely, an open space to move around, free movement of the lamp, a variety of color choices, and so on. The installation did not indicate any goal or rules for the interaction, and did not encourage or discourage specific uses of the objects or the lamps. The first re-design made the instructions more easily accessible in the physical space and introduced challenges. As a result, the installation now *encouraged* and *requested* specific behavior: such as creating a winter scene or placing three objects on the table. Thus, while the possible interactions remained unchanged, the artefact now gave some directions to the visitor. That seems to have helped visitors come up with ideas for things they could do with the installation, which helped new interactions to emerge. After the second re-design – i.e. the introduction of more houses and human figurines – visitors started to create even more elaborate tableaus (Figure 5), demonstrating creative exploration in new ways. Those new objects *encouraged* a more detailed approach by the visitors, while also supporting more complicated forms of self-expression.

In our design process we started with what the artefact *allowed* and gradually transformed it into something that the object *encouraged* or *requested*, thus, highlighting to new visitors interactions that past visitors had found engaging. However, we still designed for **flexible** types of affordances rather than **rigid** ones, in order that the installation would

stay open to re-purposing and appropriation by users. Our observations indicated that the installation became more engaging with each re-design iteration.

An important limitation for our study was the fact that the installation was temporary and had to be taken down once the main exhibition was over, which meant that we could only run the process for a limited time - and could only fit three iterations into that period. This was frustrating as we felt that the installation was only just starting to find the right shape when it had to be shut down. Ideally, we would have liked to carry the process further and explore the design through more iterations. Future research should aim to explore design-after-design processes over longer time and more cycles of iterations.

## 7 CONCLUSIONS AND FUTURE RESEARCH

In this article we have explored a design process in which we deployed an undetermined artifact with the purpose of inspiring museum visitors to re-purpose its use, and used those instances of re-purposing to re-design the original artefact. While the undetermined initial state seems to have been a source of confusion for users, the absence of constraints also helped to uncover novel behaviors. Future research should explore how to carry out similar design processes in a way which avoids that the undetermined nature of the initial artefact becomes an obstacle to engagement - while maintaining sufficient openings for users to re-purpose and re-design the artefact. If the process is not limited by other circumstances such as time, resources and stakeholder involvement, the problem outlined above may simply be addressed by extending the process in time. This entails accepting that the initial undetermined artefact may be too confusing for users, and that take-up will be slow in the start - in the hope that users will gradually discover interesting uses for the artefact, which can guide the design-after-design process in a promising direction. However, if such a slow process is not possible, the process may need to be adapted in order to progress more quickly. We suggest a few ways in which such processes may be explored in future work.

An interesting possibility which we could not explore would have been to create more radical and more frequent re-designs to explore the space of possible interactions - for instance by trying out more radical variation in the challenge prompts (e.g. "create a hellish environment"), introduce a larger variation of tangible props from different environments (e.g. space, history, mythology), or re-designing the installation itself (e.g. instead of a table set up a small house that users can enter), in order to observe what type of behaviors these very different elements would support. Such redesigns were impossible in our case due to the educational goals and other constraints set by the institution. Exploring design-after-design processes with more radical and frequent re-designs would be an interesting avenue for future research.

A different direction could be to start the process not with an entirely undetermined artefact, but rather by redesigning an existing, determined artefact to add some new affordances of the most open *allow* category [Davis 2020]. An example of how such a change might look like can be found in the design of *Drift Table* [Gaver et al. 2004], where a coffee table was augmented with a screen which displayed an aerial view of landscapes in Britain. Through shifting the weight that was on the table, users could control the movement of that view. Such an addition in an already established object resulted in users changing their routine and engaging with new table activities – e.g. embarking on long virtual trips collectively and collaborating on the weight placement to reach the destination [Gaver et al. 2004]. Another example of such a change can be found in the design of *Mood Squeezer* [Gallacher et al. 2015], where users could squeeze augmented stress balls in order to display the color they associate with their mood in a public display. That possibility of self-expression gave space for new behaviors to emerge in the work space – e.g. an otherwise private activity of squeezing the ball to relieve one's stress became social, sparking discussions and playful interactions [Gallacher et al.

2015]. Both of those cases showcase how an addition of an open, flexible type of affordance sparked new behaviors. Similarly, one could imagine a cultural institution altering one of their established determined experiences with some *open* new function. Our suggested design process would then proceed to study what novel ways of interaction those new affordances might uncover, and how we could gradually translate those affordances to *encourage/discourage* ones. Such a process might help avoid the initial state of confusion we observed in *City Lights*, and could shed light on how to balance openness and constraints in the design-after-design process.

An even more radical change in the process could be found by taking inspiration from the use of constraints as techniques for stimulating artistic creativity. This type of approach was in particular made famous by the literary movement known as OuLiPo [Mathews 1997], where for instance the author Georges Perec wrote an entire novel without the letter 'e' [Perec and Adair 2005]. However, the use of constraints to inspire creativity has also been discussed in relation to other types of creative endeavours [Elster 2005; Ingimundardottir et al. 2018; Mercier 2014], including design work and hackathons [Karlsen and Løvlie 2017; Roggema 2014; Stokes 2006]. Applying this approach would entail to start the design-after-design process with an artefact that invites users to interact according to rules that appear near impossible - in the words of Matthews, to invite users to "play hard games" in the hope that eventually, "thanks to the impossible rules, we find ourselves doing and saying things we would never have imagined otherwise" [Mathews 1997]. Thus instead of starting the process with an undetermined artefact, the process would start with an artefact that appears *overdetermined* - or rather, impossible - in the hope that this provocation may inspire users to find creative ways to re-purpose and re-imagine the artefact. For instance, in the context of *City Lights*, users might be presented with a variety of building blocks representing non-natural objects such as houses, cars, roads, machines, etc - along with contradictory prompts such as "build a park" or "create a pleasant environment for cats". Constraints could also be applied to the lights, for instance by applying sensors that would only allow the lights to be turned on when artefacts are placed in certain configurations on the table. Experimenting with such constraints would come with the risk that users might find it hard to engage due to the constraints, or that their interactions might be so constrained that the process would fail to uncover novel uses that could steer a redesign process. Such risks could be mitigated by enlisting floor staff to help users make sense of the installation, e.g. by encouraging them to break the rules.

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