Living In A Prototype: A Reconfigured Space

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ABSTRACT

In this paper, we present a twenty-three months autobiographical design project of converting a Mercedes Sprinter van into a camper van. This project allows us to investigate the complexities and nuances of a case where people engage in a process of making, transforming and adapting a space they live in. This example opens a radically different and productive context for revisiting concepts that are currently at the center of human-computer interaction (HCI) research: ubiquitous computing, home automation, smart homes, and the Internet of Things. We offer six qualities characterizing the evolving relationship between the makers and the lived-in environment: the van. We conclude with a discussion on the two themes of living *in* a reconfigured home and prototype qualities in a reconfigured space, and a critical reflection around the theme of the invariably unfinished home.

Author Keywords

Autobiographical design; Maker; making; lived-with; DIY; everyday design; IoT; Smart home.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

We present a long-term autobiographical design project of converting a Mercedes Sprinter van into a camper van. Over the past twenty-three months, we have reconfigured the space in a cargo van to allow activities like cooking, eating, sleeping and entertaining during their biking and skiing trips. In this paper, we present this project as a way to examine further and critically reflect on how people imagine, design, make, and repair an environment they live in. The core goal of this paper is to interpret insights from this project in the context of future research in HCI on the design of technologies for the home, particularly smart homes and the Internet of Things (IoT).

This project relates to previous research investigating how people live with design artifacts (digital or not) in everyday settings and how they creatively appropriate, remake, or modify them through ongoing practices. Ethnography and ethnomethodology works by Tolmie et al. [29], Crabtree et al. [10], Swan et al. [25], and Taylor and Swan [27] show how families organize, communicate, and coordinate their everyday lives through and with the help of a variety of artifacts and media in the home as part of their routines. Specifically, work by Wakkary et al. [32,34] has looked at how those artifact and system transformations are part of ongoing design processes and build on incremental engagements with artifacts and the surroundings. With design-in-use, everyday designers are able to adapt their artifacts and systems to the daily pressures of use and family members' individual needs [34]. Use is a strong motor for changes to occur, and the accessibility to resources and materials in the surroundings makes it possible for those changes to happen dynamically. While, at times, those changes can be tacit and unselfconscious [32], at other times home dwellers are aware of the value of those changes and intentionally plan and test out design variations for a specific need [34]. Our van conversion project is an example where the maker is aware of the design process and this project is a particularly rich example for how making, using, and living over time are inevitably linked.

The van conversion project offers a radically novel and productive context to explore questions regarding ongoing developments along the trajectory of research leading from ubiquitous computing [1] towards smart home research [14] and the IoT in the home [5]. As an extension of visions of ubiquitous computing [6], the IoT promises to reconfigure our everyday environments by sensing the world around us and providing connectivity to and between things, buildings, the city and beyond, our social network, and our own body [5]. Building on and extending ideas that emerged from ubiquitous and pervasive computing, the IoT also imagines how computation will continue to shift away from the desktop to becoming part of and disappear into the physical environment we inhabit, from graspable things to using architectural surfaces as active surfaces for computation [1]. As we describe later, the van conversion project is a unique example for how people can reconfigure a whole environment, its furniture, and its artifacts; *and live in it*. This project allows us to understand how all aspects of a reconfiguration are connected, and provides a strong starting point for reflecting on the current trajectory of the integration of technologies in the home.

For those who are advocates of IoT, there are still challenges for a widespread adoption. For instance, De Roeck et al. state: "in order for the IoT to really take off, end-users need to participate in the creation process on a larger scale. They need to have the power and control over the creation and use of applications for smart environments." [20:170]. As computing becomes more entangled with the things we live with and the places we dwell in, it also has the challenge of becoming highly unique, personal, and multifaceted to fit each of our lives. Proposed solutions include end-user development [28] and a do-it-yourself (DIY) approach [20] to allow users to take control over how, when and why they will integrate IoT 'things' in their lives.

Both end-user development and DIY are approaches that see people as being creators and designers instead of consumers or users [35]. The van conversion project offers a deep look into a DIY approach where people have become creators and makers. With this single case of autobiographical design, we are able to dive into details of how a complete environment is designed and made, and how the makers have lived with this space for almost two years. Although the camper van is not primarily a technological environment, nor an IoT project, it has the benefit of being easily customizable and transformable, and existing accessible tools and materials can seamlessly be used in the van conversion. The design conception and the physical transformations in the van could not have attained the same level of richness, fluidity, and detail compared to an existing technological environment or IoT system. This is mostly due to the nascent state of such systems, which currently do not sufficiently support off the shelf customization, adaptation, and transformation. We turn to the van conversion project as an illustration of a space that already encourages maker/user[1] practices as a way to investigate the complex, personal and evolving relationship that exists between the maker/user and the designed artifact or environment. This project opens a critical and reflective space for examining domestic technologies. In particular it can bring into focus qualities that may be overlooked in a more technocentric view of technology in the home. Our goal in this paper is to expand and provide details for future IoT for the home from both autobiographical researcher and maker/user perspectives.

In this paper we investigate making in an everyday context, particularly how makers live with the things they make over time. In this manner, we not only look at how one object is created or transformed, but also how it relates to other objects in the environment. Specifically, we ask the questions: *What can we learn from the evolving relationship between the maker/user and the designed lived in environment?* and *What critical perspective does the van conversion project offer on the current trajectory of the integration of technology in the home?*

Our contribution to the human-computer interaction (HCI) community is two-fold. Firstly, we offer a description of six qualities of the relationship between the user/maker and the lived-in environment. This has specific implications for future research and design in the area of the IoT and computing environments like smart homes. Our second contribution is presented in our discussion: a reflection on the current trajectories of technologies in the home under three themes: living *in* a reconfigured home, prototype qualities in a reconfigured space, and the invariably unfinished nature of the home.

BACKGROUND

Before we present the van conversion project, we provide an overview of previous HCI related research that has investigated how everyday people and makers reconfigure their own spaces and environments. The ways in which people have engaged in those transformations range from being mundane, tacit, and unremarkable to being at the center of DIY and maker practices.

Everyday reconfigurations of the home

HCI and interaction design research has been interested in understanding people's routines and organization strategies in their most intimate space: the home (e.g. [10,19,25,27,29]). In those studies, researchers often found unique and personal practices where people reconfigure the space around them, including the artifacts within it, to fit their family's needs and activities. An important insight from these studies is that the systems created by families are often only intelligible to themselves and are so well integrated into routines that they often become invisible or unremarkable [29]. The study of everyday design [34] investigates the incremental and ongoing processes of living with design artifacts in the home, and particularly how people may creatively and resourcefully adapt or transform them to better fit their everyday routines and needs. The work on everyday design highlights that systems in the home are often heterogeneous, unique, dynamic, and personalized. This echoes findings by Taylor and Swan [27] who also bring attention to the lived experiences in the home and the material properties of artifacts in households. Collectively, this work emphasizes how design and making are ongoing processes that are part of everyday routines, how the material aspect of those practices are central to their working, and how everyone can be a designer and maker.

The study of mundane and tacit design coincides with the description of unselfconscious cultures described by architect Christopher Alexander [3]. In unselfconscious cultures, design and architecture are not professions, but rather something that is performed by everyone, following the traditions of family and ancestors. In those cultures,

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[1] Throughout the paper, we use the term maker/user to refer to the people who simultaneously design and build a new artifact, system, or environment by creatively and resourcefully using materials and tools; and live with the designed artifact, system, or environment over long periods of time.

design is an integral part of everyday life, where small fixes and changes are performed in an ongoing manner as a way to reach a better design (or a goodness of fit between what is designed and the context). In [32], Wakkary et al. revisit characteristics of unselfconscious cultures and present the conceptual construct of unselfconscious interaction, a form of interaction that enables ongoing and incremental engagements with an everyday setting, leading to goodness of fit. A supporting notion to the construct is the quality of *lived-with*: the idea that it takes time for those interactions to emerge and take place, and that it is through co-inhabiting with artifacts that home dwellers can eventually see them as resources for further design action.

The analysis we present in this paper builds on this previous research. While the major design acts in the van conversion project are not tacit, unselfconscious, or mundane (they are rather in the realm of DIY practices, as we describe in the next section), some qualities of ongoing design processes and the long-term relationship between the maker and the environment as described here are central to what we have observed in the van.

Do-it-yourself reconfigurations of the home

Do-it-yourself (DIY) enthusiasts and makers share the common practices of designing, appropriating, and transforming existing products to better fit their own needs, lifestyle, or aesthetic tastes. Makers have been of interest to HCI for the alternative and critique to mass production and consumerism of personal technologies they provide (e.g. [2]). In addition, the study of makers has provoked deep reflections on the ways they expand both the definition of the user [35] and the definition of the designer [33]. In this paper, we refer to maker/users: a term that invites the reader to consider a user to be simultaneously using and making (or remaking) an artifact or a space, hence combining the two actions into a unique identity.

More specifically, studies of maker and DIY cultures push the boundaries of our understanding of the relationship between people and design artifacts and technologies by foregrounding themes such as identity, empowerment, creativity, and resourcefulness. In the past years, the HCI community has been studying maker individuals and communities to gain insight about how to create interactive technologies that better support their design and making practices (e.g. [15,17,21,26,36]) as well as to gain inspiration for designing future personal technologies. While DIY and maker ideologies aspire to inclusion and technology democratization [26], we wish to highlight the distinction between the types of reconfigurations that 'everyone' can do in the everyday (as presented in the section above) and more involved reconfigurations performed by makers or DIY enthusiasts [4,30], as illustrated in our van conversion project.

True to its origins in home improvement [24], DIY has been investigated in the context of smart home and home automation, and more recently as an approach to IoT in the home. In those contexts, DIY is not only about the reconfiguration of artifacts, but also spaces and environments. Dautriche et al. [11] champion the idea of bringing end-user development to smart home systems. In this way, they argue that people will have more control and will be able to create and adjust the system to their own needs. Commercially available systems like Twine [38] and Ninjablocks [39] are DIY kits that allow people to install sensors and actuators around their house and to program rules to activate them. Woo and Lim [37] have studied how people use these DIY kits for home automation in a three-week deployment study. They describe the usage cycle as follows: "*initial installation*, *motivation*, *implementation*, *use-through-routine*, *routinization*, and *removal*" [37:783]. In addition to DIY kits, we see in Casa Jasmina [40], a project by Arduino, an example of a house designed to be open source, connected, and part of the IoT. With this project, the team hopes to see how people can live within a space that encourages the making of artifacts that will become part of the home. These recent examples show that there is interest in incorporating a DIY approach to smart homes and other environments.

Through this brief literature review of HCI research on everyday and DIY reconfigurations of home, we have highlighted how people actively, sometimes tacitly, engage in the adaptation and transformation of their own artifacts and dwellings over time. This research foregrounds the role people have in shaping their environment to better fit their identities and needs. However, as Verbeek [31], a philosopher of technology, has articulated: those artifacts and technologies also have an impact and a role in mediating between people and their actions in the world. In this paper, we are interested in understanding the qualities of this two-way, co-shaping relationship between what is being made and the maker/users.

OUR STUDY

Our goal with this paper is to investigate what it is like to live in a reconfigured space for the maker/user. More specifically, we want to understand what are the qualities of the relationship between the maker/user and the design artifact that is built and lived in.

We want to note here that while this paper is a collaborative effort with multiple authors, Desjardins and Wakkary, the latter author did not participate in the van conversion. Further, Bérubé Lebrun, Desjardins' partner, participated in the van conversion and autobiographical design but is not an author or researcher in this paper. Despite these multiple and different contributions, we decided to use the authorial voice "we" to refer to both authors and participants. We feel justified in this approach since the first author, whose contributions we rely on the most in this paper, is both author and autobiographical design participant. This allows us to adhere to our methodological commitment to autobiographical design research (see Methodology) in which we report in the first-person perspective (in our case

in the plural form), and acknowledges the fluidity of insights that occur during the experience of the autobiographical design by participants and on further reflection by participants and researchers.

The Van conversion project

This study reports on the first twenty-three months of building and living in the converted van. This is a project the first author Desjardins and her partner Bérubé LeBrun started alongside their day time jobs: Desjardins is an interaction design researcher trained in industrial design and Bérubé Lebrun is a landscape architect with eight years of professional experience and woodworking skills. The maker/users in this case have had extensive design training, which distinguishes them from non-expert designers.

We bought a Sprinter van in October 2013 with the intention of converting it into a camper van for camping and ski trips. The van was new with nothing else in it other than the driver and passenger seats. The walls were not finished; they were the bare metal sheets. The back of the van represented a space of approximately 6 feet wide by 10 feet long by 6 feet tall. The complete van conversion was planned over five years with different stages such as adding a complete kitchen unit, electricity, water, solar panels, etc. Each stage includes breaks that allow us to live in the van and go skiing, mountain biking, or camping; however small changes, additions, and repairs are ongoing, even while traveling with the van. To date, the van has been through four major building stages: insulating the walls, creating a back platform for storage, finishing the walls with cedar tongue-and-groove panels, and building a unit that serves as benches and a table that converts to a bed (see figure 1).

The van conversion autobiographical design project potentially offers deep insights into how a maker/user builds and lives in a delimited environment. We chose this case because we were able to follow each step as it occurred, from buying the van to the most recent build and trip. In addition, the van offers a circumscribed area where all the transformations and living occur. This enclosed, contained environment accentuates characteristics of living in a prototype over time. Although the van conversion project may share similarities to home improvement or home renovation projects, we note that a home is rarely renovated as a whole while people live in it. Finally, the van also allowed us to observe not only aesthetic transformations, but also functional and technical adaptations, such as the storage platform, the installation of a new radio and speakers, and reflections on the electrical system of the van. We reiterate here that we believe the van is a useful case to study as a way to understand the deeply personal and rich practice of maker/users in environments.

Methodology

The conversion of this van was never intended to be research; it was meant to be the process before we were ready to hit the road and travel, camp, ski, and bike. However, this project offers a rare opportunity to take an in-depth look at how people live with (and in) the things they make. It allows us to extract many of the sensibilities and nuances of the intertwined processes of making and living, and to identify qualities of the relationship that exists between the maker and the thing that is made. As the project moved forward, it became clear that it was revealing and illustrating issues and matters of concern that were relevant to HCI research. Hence, we use an autobiographical design approach to present those insights in this paper.

Autobiographical design is defined as "design research drawing on extensive, genuine usage by those creating or building the system" [18:514]. Neustaedter and Sengers [18] argue that successful autobiographical design needs to fulfill a genuine need, the system needs to be lived with over a long period of time, and the designer needs to be the user of the system. All those criteria are fulfilled with the van conversion project. Neustaedter and Sengers' study shows that this type of design research can support fast
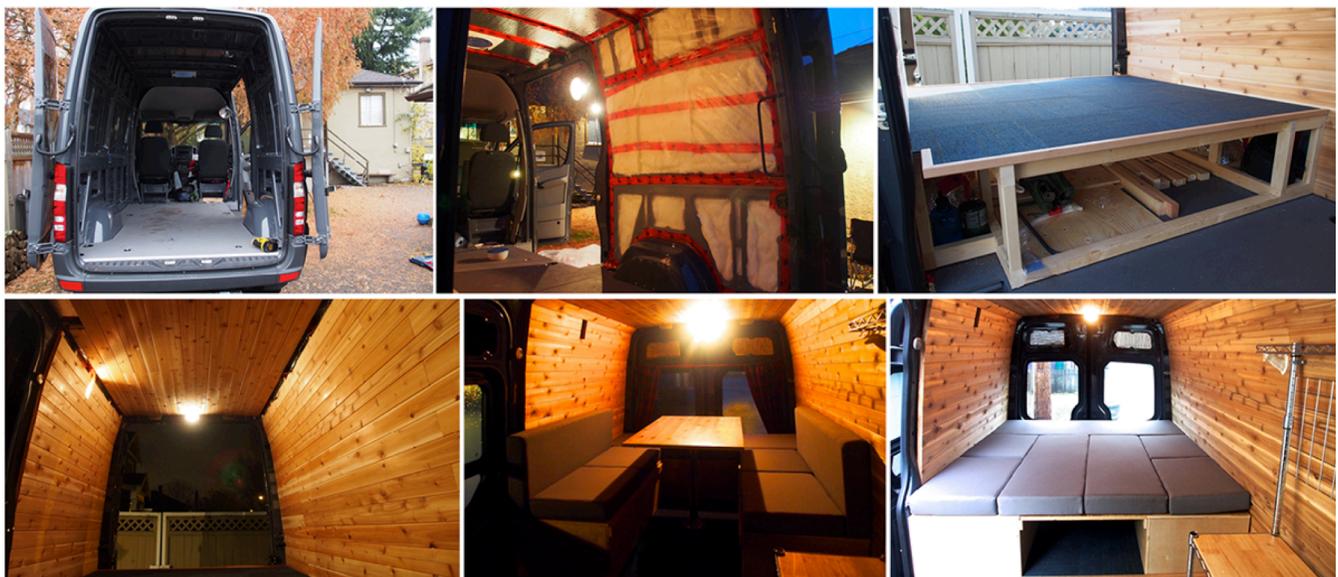
Figure 1. Building steps: From top left: the empty van; step 1 – wall insulation; step 2 – back storage platform; step 3 – wall finishing with cedar panels; step 4: benches-table-bed unit in a) table position, b) bed position.

tinkering, requires and tests real systems beyond concepts, can provide detailed and experiential understanding of the system, and reveals the big effects of a system. Interestingly, in our view, the autobiographical designer is by definition a maker/user as well, because he or she embodies both the making aspect as well as the living with aspect of the maker/user.

Autobiographical design offers a lot of potential for studying complex, long-term, personal situations, such as the practices of maker/users in lived environments [12]. In addition, it allows us to gain insights into the making and design aspect of the van conversion, as well as the iterative experience of living with it over time.

Data collection

As Neustaedter and Sengers state, record keeping and data collection are unusual in autobiographical design [18], since projects are often not seen as research projects while they are being made or used. The van project conversion is an exception. We had an extensive process for gathering data about the fabrication of the van, the different steps of making, and about living in the van as well. The data gathered was not aimed at generating a research account, but rather to create documentation about the design process to share with other DIY enthusiasts and the community invested in converting campervans. The data gathered included:

- Tutorials on the Instructables web platform for each important fabrication stage. Tutorials were created for the wall insulation, the construction of a storage platform, the finishing of the walls with cedar panels, the construction of benches and a table that convert into a bed, and the making of cushions for the benches and bed.[2] The tutorials have received between 33,000 and 178,000 views to date.

- The Instructables tutorials required photos of each step in the making, including tools and materials. Those photos also show the finished product at each step.

- Within the Instructables tutorials were also added timelapse videos[3] of each day of building. Photos were taken every 30 seconds and then assembled to make short videos. There are a total of 17 videos to date.

- The Instructables tutorials also hold a record of readers' comments and questions, and the authors' answers (total of 169 comments and replies to date). Questions often led to reflections on design decisions and current living practices in the van.

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[2] http://www.instructables.com/id/How-to-insulate-a-camper-van/
http://www.instructables.com/id/Storage-platform-for-the-back-of-your-Sprinter-van/
http://www.instructables.com/id/Cedar-paneling-for-van-interior/
http://www.instructables.com/id/Bed-Table-and-Benches-for-camper-van-All-in-one/
http://www.instructables.com/id/How-to-sew-cushions-for-a-camper-van/
[3] https://vimeo.com/album/2607513

- Short diary logs that record the dates, places, and important events of the trips made in the van.

- Photos of the van's interior while on trips, focusing on different activities like cooking, eating, playing games, sleeping, and getting ready for outdoor activities.

- Blog post of some of the trips on the site www.go-van.com as travel reports.

Data analysis

The data was organized by creating a thematic analysis that grouped data points following how they characterized and qualified the relationship between the maker/user and the environment of the van. Themes such as intimacy, shaping the maker, dialogue, arguing, taking care of, getting to know you, knowing you too much, dreaming up a future, pride, and timing were developed. In a second analysis iteration, those themes were revisited and some were combined into six qualities of living in a prototype, as presented in the following section.

QUALITIES OF LIVING IN A PROTOTYPE

In this section, we describe qualities, or characteristics, of living in a prototype. These qualities emerged during the process of making/using but concretized in later reflections and analysis of the experience and data. Those qualities describe the intimate relationship that has taken shape between the maker/users and the prototype, or in this case, between Desjardins and Bérubé Lebrun and the van as it is being converted.

Reciprocal shaping

In a long-term personal project, we have observed that not only the project changes over time, but we change as well. We call this quality of the relationship between the maker/users and the environment: *reciprocal shaping*. This is not far from the idea of reflective conversation, first theorized by Schön [22], but goes beyond the observation that materials may have a say in how they are formed and shaped. In the case of the van project, we have noticed that by living in the van as it is constructed, we have changed our expectations for what a van is (or should be), and our predicted or expected needs.

Firstly, we observed how our bodies (dimensions and flexibility) dramatically influenced how things were designed in the van. For example, when shopping for the van and doing a road test, we stopped the van and lay on the floor in different positions to imagine how the bed could be positioned. Later in the process, we also followed our personal bodily dimensions to balance the height and depth of the benches and table on the back platform. Decisions were made based on physical comfort, and it is important to note that in this case comfort was defined accordingly to the only two users who would live in this van.

Simultaneously, as we made decisions about how to build the van, the van itself gave hints and suggestions for how to build the next steps. By slowly designing and adding

Figure 2. Evolution of the furniture.

different parts to the environment we were living in, the time allowed for reflections on our needs. We started this project with expectations and ideas of what a converted van was and how it resembled a small recreational vehicle (RV). For example, for both of us, it was clear that the van would eventually need electricity through a secondary electric system to support lighting and a fridge. However, as a convenient solution while waiting for the time and resources to install an electrical system, we developed alternative strategies to support our electric needs such as small portable solar panels, rechargeable batteries, and a camping cooler for the food. After almost two years of living with the 'alternative' system, we realized that electricity (in the form we had envisioned) might not be necessary anymore. The realization that having less than expected might work better for us occurred only because we lived in the van over a long period of time, in a manner we had not imagined. The luxury of having time to deeply know our needs influenced greatly how the rest of the van was built.

Intimate knowledge and intimate frustration
The quality of *intimate knowledge and intimate frustration* refers to the deep personal connection we have with the van. It is a strong relationship and a profound understanding for how things are in the van. For example, when driving, we can hear different sounds like creaking and rattling depending on how things are positioned in the van. However these sounds vary with the temperature and the weather (heat and humidity make wood and metal expand and shrink at different rates). After twenty-three months of building, living, and driving in the van, we have learned where these noises come from, and we now know how to make them stop by rearranging objects in some cases.

However, with intimacy can also come frustration. As much as we know where the sounds come from when driving the van, there are some noises we know cannot be changed, since they are related to how the van was built, particularly how different sections are connected together (such as the storage platform and where it touches the cedar panel walls). Since the project follows a trial and error process, we are able to adjust the next steps in building to reduce noises, however for some noises it is impossible to go back and make adjustments now. In a way, the earlier builds served as prototypes for future builds where we were able

to adjust the technique based on previous mistakes, and to share it with others through our Instructables tutorial:

"*Also, **more importantly**, we left at least a 1/4 inch between the benches and the walls. From our previous experience with the platform and the cedar walls, if things are too close together but not attached together, there is so much creaking and rubbing noises when we drive that it can drive us crazy! For the same reason, we also added small felt auto-adhesive pads between the side benches and the back bench, to prevent them from being too close together.*"[4]

The intimate frustration is accentuated when we share our concerns with others who do not have the same intimate knowledge of the van. For example, after the first winter, the side door started to make more creaking noises when driving. These noises were quite specific, but they were happening at the same time as other noises were produced from the platform touching the cedar panel walls. We brought the van back to the van dealership to have the door checked. After two test runs, the mechanics still concluded that the noise was only coming from the wood platform and walls that were added. It was impossible to show or communicate the noise that we had heard.

Intimacy is also about developing routines for camping in the van that are gained over time. For example, knowledge for how to pack the van or knowledge for how to be most efficient when cooking comes from multiple days of living in the van. These are hard things to share with others who have not lived in the van, even if explained in words or with demonstrations. For example, on a weekend trip, one of our friends from out of town shared the van with us. Although we managed to do everything we needed to accomplish, things needed to be verbalized and explained with patience. This revealed the deep intimacy that is shared only between us and the van, something that is often invisible to the eyes of others.

Renewed novelty
The quality of *renewed novelty* describes the sensation of novelty experienced whenever a change is made in the van. This is a similar feeling to getting accustomed to a new piece of furniture in a home or the freshly painted walls of a room in a different color.

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4   http://www.instructables.com/id/Bed-Table-and-Benches-for-camper-van-All-in-one/

Renewed novelty was felt the strongest after making important changes to the van, such as adding the storage platform, finishing the walls, and adding the benches and table (see figure 2). In such cases, we had worked for a very long time on the making of each step before trying the results out. This meant that for two or three weekends in a row, we had been focusing on the making rather than the living in the prototype. Once a step was concluded, a palpable excitement was felt as we planned a weekend trip to try it out. Each first time living in the van again was also a rediscovery of the van itself, or perhaps it was a different version or iteration of the van.

Moreover, we noted that this sensation of renewed novelty was not only experienced with large changes, but also with small subtle additions to the van. The intimate knowledge of the van, as described earlier, is deeply tacit and any small change has an important effect on how we felt about the van. For example, in January 2015, more than one year after starting the conversion, we installed two hooks on the ceiling on the van to allow for hanging a light and its wire. Even though lights had been used and positioned in various places in the van previously, this slight change created a new feeling, one that was more homey, and that expressed how much more settled we were in the van at this point. That small change also transformed how other activities were performed, such as cooking, eating and hanging out.

After each incremental improvement, in addition to the feeling of accomplishment, we also found ourselves dreaming about the next building stages almost as soon as we tried current versions of the van. This imaginative process was catalyzed and supported by the now existing newly added pieces to the van. Instead of envisioning multiple steps ahead, the current version of the van offered a strong anchor to explore possibilities of future design and builds. This finding echoes recent literature on prototypes that argue that the value of the prototypes lies in how it manifests a design idea [16].

Ownership and change
One of the main qualities of our relationship to the van is ownership. Ownership influences how we manage and deal with changes in the van over time. Contrary to most research artifacts deployed in field studies, the van is something that we own. Knowing that the van cannot be returned to the store after its transformation provides a sense of freedom, while also adding more responsibilities. For instance, ownership has an important influence on the choice of the materials, the quality of the materials, the attention to the craftsmanship and detail that is put into making the different changes in the van. As we were making decisions about what material to use to finish the walls, we knew that this was going to be a main feature and would be value-added to the van. Even though tongue-and-groove cedar panels were a good choice for durability, sustainability and style, they were not an easy choice in terms of installation or price. We needed to drill into the metal frame of the van to install wood studs before nailing the cedar panels into place. Regardless, we were thoughtful when planning how we would install the cedar panels, made a small set of test pieces, and then spent over 25 hours installing the panels.

As owners, we also made decisions about how permanently or temporarily certain elements should be installed in the van. A balance between how committed we are about a change, the ease to install and uninstall, and the time and monetary resources has to be found before a change is made in the van. For example, with the cedar paneling, even though the installation was complicated and time consuming, the final result is intended to stay for the life of the van. The motivation to have beautiful and well-made walls was strong enough to encourage us to put the effort and time into crafting them purposefully and to think through all of the fabrication details.

Yet, in some cases, temporary solutions needed to be installed in the van to support important activities. For instance, a simple kitchen unit was necessary since the first trips to be able to prepare meals in the van when it is too cold or rainy outside. Before putting the time and effort into building a kitchen unit fully furnished with stove, fridge and sink, we wanted a temporary solution that would give us time to live in the van before making any decisions. We bought a pre-made simple kitchen unit (with 3 shelves and a counter top) from a large retail store (see figure 3). We simply used c-clamps and attached the unit's posts to the wall and floor with screws. This simple solution works well as a temporary solution, but also as a 'sketch' for what we could build when they create the 'real' kitchen unit.

In terms of ownership and the various versions of elements in the van, the van is not a traditional prototype, one that stands as a representation of something to be made in the future. Some decisions lead to permanent installations, which, in turn, influence how future elements are designed. At the same time, it seems also evident to 'prototype' within the van, to try elements of the future design, as exemplified by the kitchen unit. We return to the question of sketching and prototyping in the discussion section.

Figure 3. Kitchen unit as a temporary solution. (Left) as it was firstly installed, and (right) after the walls were finished.

Care and trust

The qualities of *care and trust* in the relationship between the prototype and the maker/users are strong underlying ties that take time to grow. Care included maintenance of the van, such as changing summer tires to winter tires, changing burned lights, and retouching the paint of the hood for rock chips. In this sense, we see maintenance as part of how we care for the van, similarly to how Gaver attended rapidly to a repair he needed to do on the Video Window [13] (another example of autobiographical design). Care was also about how we treat the van on the road, for example by being very cautious on backcountry roads that can be rocky, steep and snowy. When taking a challenging route, we felt proud when the van was able to transport them without any problems. By constantly driving the van, a sense of trust developed, the trust that the van can 'take it' and that it is possible to explore with it further and faster.

Trust also developed in and about ourselves. We learned how to secure and attach things to the van, how to build things in the most efficient and safe ways. Since this project is the first one both of us have ever done of this type, we needed to build trust in ourselves and with each other that we had the proper skills to transform the van the way we wanted. The first time we drilled in the van walls to install studs to support the cedar panels, it was a stressful moment, but we eventually realized that our technique was working and we could move along with the process. This trust in our own skills also relates back to the quality of *ownership and change* since the care for the van goes hand in hand with the sense of responsibility present with ownership. Care was also demonstrated when we wanted to make important changes to the van but did not believe we had the proper skills, such as cutting metal to add windows to the doors or a fan to the ceiling. In such cases, we hired professional help specialized in camper conversions to do the job. This is an example where the care for the van was strong enough to push us to seek external help.

Trust in our own skills was also assessed when writing the tutorials online. We were aware that we are amateurs and wanted to make sure readers of the tutorials did not take us for professionals. This is illustrated in the disclaimer that we added at the beginning of each tutorial:

Figure 4. Laser cut paper deer head and watercolor of the cabin that inspired the van conversion project.

"*DISCLAIMER: This is the first van conversion we are doing, so this is certainly a process of trial and error! We tried to describe at every step the reasons why we made the material choices we made, so hopefully you can see that we used common sense to design this process. I am an industrial designer and design researcher and my boyfriend is a landscape architect with some knowledge in wood working. We see this project as an experiment and as a wonderful place to try out some ideas about design, materials and fabrication.*"[5]

Growing uniqueness

The quality of *growing uniqueness* highlights how, as the prototype becomes more and more unique to the maker/users, it also becomes less and less suitable for any other users. The ongoing process of living and making in the van, augmented by the quality of *reciprocal shaping*, has led to a nuanced and detailed understanding of how to build for usability and functionality in the van. Similar to what has been observed in everyday design [34], systems used in the van are often only intelligible and make sense fully to its inhabitants. For example, every object has its own place in the storage bins and areas. These positions have been developed over time, based on space, size, but also on how noisy things are when driving, and when and how or when each thing has to be used in the van.

In addition to finely adjusted functionality, we are also designing for our own aesthetic taste, influenced by places we have lived in before, places we have visited, and our own preferences. In the case of the van, we had rented a small blue A-Frame cabin for 2 winters before buying the van. This A-frame was our ideal of what a cabin in the woods should be: cozy, filled with wood and with the smell of cedar. Our experience in that cabin, along with the memories it carries, was the inspiration for many decisions in the van, including the warm materials like cedar panel walls, the plaid curtains and cushions, as well as the wooden table. For example, this is how we presented the cedar panel step in the Instructables tutorial:

"*We love skiing. We love mountain life. We love the feel of rustic cabins. We love the smell of cedar. We wanted a real cabin on wheels. This means there was only one material we wanted to use for the walls and ceiling of the van: CEDAR PANELS!*"[6]

In addition, decorative elements such as a paper laser cut deer head and a watercolor painting of the initial blue A-frame cabin were added to the walls (figure 4). Although these elements can be visually appreciated by others, their real significance is only felt by us.

Six qualities of living in a prototype

The six qualities described above are unique to this autobiographical design project and were rarely pointed at

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[5] http://www.instructables.com/id/How-to-insulate-a-camper-van/

[6] http://www.instructables.com/id/Cedar-paneling-for-van-interior/

in previous literature on smart homes or the IoT for the home. For us, this gap indicates an opportunity for future research in HCI, where researchers can use these qualities as lenses to orient their designs. The six qualities as a group highlight themes such as designing for and supporting household uniqueness, enhancing a sense of self and at the same time a sense of responsibility towards the space, and finally acknowledging how small and subtle changes in the space can have important and big impacts on the ways of living in the space. In addition, those six qualities speak to the maker/user *in a space* rather than *with* artifacts in isolation. The findings of this paper make clear the kind of qualities such a relation can have and this contributes to a reframing of discussions in the trajectory of the design of technology in the home, from ubicomp, to smart environments, to IoT, as we will outline below.

DISCUSSION

In this section, we use the six qualities of the relationship between the maker/user and the lived in environment to reflect on how the van project can support and move forward the research fields of IoT and smart home. With this discussion, we answer our first research question: *What can we learn from the evolving relationship between the maker/user and the designed lived in environment?* We present our reflection under the two themes of living *in* a reconfigured space and championing the prototype qualities of a reconfigured space.

While we see the potential and promise of IoT, the simple, slow, and piecemeal design process of the van can also trigger more critical reflections on the current trajectory of the design of technologies for the home. With these reflections, we address our second research question: *What critical perspective does the van conversion project offer on the current trajectory of the integration of technology in the home?* Our critical reflective view is articulated under the theme of the invariably unfinished nature of the home.

Living *in* a reconfigured home

Our understanding of the complex relations and connections existing between things and the environment of the van offers a constructive anchor to reflect on the evolving visions along the trajectory from ubicomp, to smart home design and IoT. We bring specific attention to the physical immersion in the space and the long-term engagement within the space.

Physical immersion

Living in a prototype means to be surrounded by the project, to be physically immersed in the thing that is being designed and built. This particularity transforms the maker/user's perspective by providing constant cues, no matter where he or she is looking, for what could be improved, changed, redesigned, or crafted in a better fashion. This sensation that everything could be changed is supported by the ability to control, conceive and build all aspects of the lived in environment. For instance, in the van we aimed at creating an overarching aesthetic, across the

ensemble of different elements added. Similarly, functional relations between things are also central to living and building the prototype, with a particular focus on how things work together and how to prevent interference between things (e.g. the creaking noises in the van).

The current IoT discourse aims to connect things to things but often neglects to account for the broader lived-in environment where those things are situated. The immersive physical experience of living in the van suggests that while interaction designers certainly design the relation between computational things, they should also pay particular attention to their relation to the environment and other systems and non-computational things already in place.

Temporality

In addition, we see implications in terms of temporality and the long-term making, using and living cycles in the van. This particularly long design process (the van conversion project was planned over a five-year designing and building process) diverges importantly from the fast pace user-centered design model that is commonly used and reported on in HCI research. The scale of time allows for a different relationship to the project and for a rich co-shaping between the van and the maker/users to emerge.

As we described in the *reciprocal shaping* quality, the capacity to have time to live with multiple versions of the van before making decisions about next building stages is a luxury that is rare in the practice of design. By living with the prototype, and by reevaluating our needs, we, as the maker/users, are able to know exactly what we want to build, find the proper materials and tools, and then build it in unique self-determined ways. The time spent in the prototype also enables us, the maker/users, to become accustomed to it and to grow and nurture intimacy as versions of the van accumulate and change through incremental adaptations and reflections. It is the temporal aspect of living in a prototype that creates the relationship for the sensibility on what changes to make in the van. It is precisely this constant back and forth between living and making over time that makes the maker/user such an expert in designing a space for him or herself.

The long term and slow incremental process of living and making in the van suggests that time can allow for a deeper relationship to form with the reconfigured space. This is an interesting reflection that proposes that future IoT development should also support a longer temporal scale and allow for maker/users to engage and re-engage over time with the artifacts and systems created.

Prototype qualities in a reconfigured space

Throughout this paper, we have referred to the van as a space, an environment, and as a prototype. Even though the van is not a 'prototype' in the common definition of the term (it is not a version of another van that might exist in the future [8]), we have observed many similarities to

qualities of prototypes and prototyping activities that allow us to rethink future developments in IoT for the home.

Firstly, the van, at every stage of the construction, is a manifestation of a design idea [16]. We saw that through its presence and existence, the van dramatically influences how we made and used it, as illustrated by the quality of *ownership and change*. However, the van is not a single artifact, it is a combination of a space, furniture, and artifacts, and each designed thing in the van can attain different levels of refinement, between roughly sketched ideas to polished details. This combination is rich in contrast and can also serve as a point of friction to spark new ideas, new iterations, and future designs in the designed environment. The van conversion project is a productive example of how prototypes (or sections of prototypes) can serve as filters [16] to focus on specific design elements of a larger project that can be iterated on, manipulated, widely explored and even polished, while still ignoring other unfinished details in the space.

Secondly, even though the van might not be a prototype in the traditional sense of the term, it is interesting to consider how prototyping or sketching activities occurred in the van. Examples include the pre-manufactured kitchen unit as a simple, cheap, and straightforward way to prototype a future kitchen, the quick and dirty enactments for our sleep positions in the van and an improvised solution for curtains while on trips as the start of a series of improvements. Through these examples, we noted how the level of craftsmanship varied depending on how 'sketched' an element was or not. Hence, when we knew an element would be changed eventually, we spent less time, energy, and care in giving it a high level of finish.

Our reflection on prototype qualities in the van conversion project reiterate the identity of maker/users, an identity that embraces roles beyond use and customization, to create a substantial role for an evolving design process within the space. We see an opportunity for future IoT research to support better prototyping activities with connected artifacts and spaces.

The invariably unfinished home
Our critical reflection on the current trajectory of the integration of technology in the home centers on the idea of unfinishedness: the notion that a lived in space (or parts of that space) might never attain a high level of finish. Similar to the common understanding that home improvements are never finished, we saw in the van conversion project a clear illustration of how it is part of the nature of living in a reconfigured space to want to continuously change and incrementally adapt to everyday living practices. This echoes the findings in early studies of home life (e.g. [9,25,27,34]). The notion of unfinishedness allows us to start to paint a new picture for what IoT systems and artifacts might be in the future that challenges current visions. By accepting unfinishedness, this new picture welcomes and creates space for the maker/user who has

agency in the creation of the unique space of his or her home.

As we presented in the last section, the van project allows us to think about the reconfiguration of the home to include various ongoing stages of prototyping. It also showed how the prototyped and unfinished sections of the van became part of the everyday and how we, as maker/users, became familiar to the various levels of finish in the van. At the same time, this ability to grow accustomed to the prototype could eclipse unfinished details, missing parts, and even inconvenient parts of the design. Through exposing unfinished elements and by embracing an unfinished aesthetic in the van, we as the maker/users set the scene to allow for a unique and deeper relationship with the space to emerge. Similarly to how unfinished design can invite more creativity on the part of end-users (as suggested in [23]), we can imagine how championing unfinished smart homes and IoT systems can support better maker/user practices. Overall, this suggests a more piecemeal, long-term, and incremental pace for introducing and implementing various elements of the IoT in home dwellers' spaces.

CONCLUSION
By building on the autobiographical design project of converting a van into a camper van, we presented six qualities of the maker/user's relationship with a lived in prototype. This work deepens our understanding of maker/user practices in general, but more importantly sheds light on how maker/users reconfigure their dwellings. We see this work to be in line with broader ongoing initiatives in the HCI community to move beyond designing for usability and efficiency and towards leveraging and enabling the creativity that people might have with regards to their own practices of 'making home'.

Our reflection grounded in the van conversion project led to the two points of living in a reconfigured home and the prototype qualities in a reconfigured space. With this discussion, we see in our work a contrasting vision to smart home design and IoT developments with regards to the ways in which people (or rather maker/users) reconfigure their homes. As a final thought, we meditate on Bell and Dourish's [7] proposition that past visions of ubicomp and smart homes might not have materialized the way the HCI field has collectively imagined, and that future technologies for the home might never look or feel like those visions. Instead, for new visions and inspiration, we might need to turn to today's unfinished, sketched, simple, and rich instances of how people reconfigure their everyday environments around the complexities and nuances of everyday life.

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