

Lundbjerg, E. H., von der Osten, J. P. Kanto, R., Bjørn, P (2017): *The Hackerspace Manifested as a DIY-IoT Entity: Shaping and Protecting the Identity of the Community*. In: *Proceedings of 15th European Conference on Computer-Supported Cooperative Work - Exploratory Papers, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591)*, DOI: 10.18420/ecscw2017-5

The Hackerspace Manifested as a DIY-IoT Entity: Shaping and Protecting the Identity of the Community

Ea Lundbjerg Hansen, Julie Pflug von der Osten, Rosita Kanto
IT University of Copenhagen, Denmark
{*eluh; jpfo; rkan*}@itu.dk

Pernille Bjørn
University of Copenhagen, Denmark
pernille.bjorn@di.ku.dk

Abstract. This paper explores how cooperative identity is produced and preserved within a Hackerspace in Denmark. Specifically, we explore how the cooperative identity emerges conceptually and physically as a ‘DYI-IoT’ entity shaping the activities in the space. We argue that the cooperative identity of the Hackerspace was created through participants’ interests and ideas expressed through their commitment to the space, which turns into productive dependencies demonstrating individuals’ attachments to the space. Our data demonstrates that an exclusive mechanism was inherent in the collaborative dynamics producing the identity of the Hackerspace. While the participants were open and welcoming, the exclusive nature of the cooperative identity emerged in their practices, and was fundamentally about protecting the cooperative identity of the space. Hacking of the physical surroundings serves as affective bonds between the participants, artefacts, and the Hackerspace. People who could not participate in the hacking activities were not able to create these affective bonds, thus failing to contribute to shaping the cooperative identity of the Hackerspace.

Introduction

The cooperative practices within Hackerspaces (also referred to as Makerspaces or FabLabs) are receiving increased attention in the CSCW community (Fuchsberger, Murer et al. 2016). In example, studies of Hackerspaces related to innovation (Lindtner, Hertz et al. 2014), cultural production (Fox, Ulgado et al. 2015), peer learning (Moilanen 2012), and public life (Taylor, Hurley et al. 2016) have provided interesting insights. Our interest is to extend prior work by investigating the basic nature of the cooperative practices taking place in a Danish Hackerspace named CoLab. In particular, we want to explore *how the cooperative identity is produced and preserved in a Hackerspace?* The cooperative identity of a Hackerspace plays an important part in defining what kinds of activities that can take place in the space. Clearly, hacking activities in a refugee camp (Stickel, Hornung et al. 2015) have different conditions than hacking activities in a public place (Taylor, Hurley et al. 2016). In Fall 2014, we initiated an ethnographic study of CoLab in Copenhagen, Denmark. CoLab is fundamentally egalitarian in nature, has a decentralized power structure, and the borders between work, leisure, and friends are blurred and seamlessly intertwined. It is not grounded within educational, activist, or commercial interests – instead it is a space for grassroots hackers, who share a common interest in technology and in making ‘cool stuff’.

We identify two sets of activities, which are constitutive for how the cooperative identity of CoLab is produced and preserved, namely shared commitment towards 1) continuously innovating the physical surroundings (e.g. doors, floors, refrigerators, and bathroom); and 2) constantly re-negotiating the cooperative characteristics of the space protecting the fragile community of conflict-averse participants without stating explicit policies and rules for interaction. Furthermore, we argue that the cooperative identity is manifested in participants’ joint dedication towards innovating the Hackerspace into a comprehensive ‘DIY-IoT’ (‘Do-It-Yourself-Internet-of-Things’) entity. The DIY-IoT entity guides and structures the collaborative engagements. It is through this joint project that participants’ commitment to CoLab turns into productive dependencies expressing individuals’ attachments (Dantec and DiSalvo 2013) to the space as a concept and physical facility. Innovations of the physical surroundings serve as bonds between the participants, artefacts, and the space, and are thus constitutive for the cooperative identity of the Hackerspace.

The paper is structured as follows: First, we present existing research on Hackerspaces and introduce our focus on cooperative practices. Second, we outline our methods and the data sources. We then present the results of our ethnographic work examining routines and practices. Finally, we discuss our findings and present our conclusions.

Cooperative work in Hackerspaces

Looking across previous literature on Hackerspaces, cooperative engagement related to knowledge sharing and expertise (Wang and Kaye 2011, Bardzell, Bardzell et al. 2014, Wakkary et al., Schilling et al. 2015), care work and marginalization (Weibert, Marshall et al. 2014, Fox, Ulgado et al. 2015, Sun, Lindtner et al. 2015) have provided interesting insights into the cooperative practices, which take place in Hackerspaces and shape the social organization of work (Ames, Bardzell et al. 2014). Knowledge sharing, skills, and expertise are important parts of the cooperative work in Hackerspaces and the way e.g. self-made digital tools are created (Bardzell, Bardzell et al. 2014) and documented as innovations for others to use through tutorial authorship (Wakkary, Schilling et al. 2015). Knowledge sharing and expertise is a community effort across both locally shared spaces as well as global networks of individuals. A central element in this community effort is meaning-making and identity development in the community of practice (Lave and Wenger 1991). Identity in a community of practice is accomplished through the dual activities of participation and reification in the everyday interaction. The duality of meaning between participation and reification, comprises “[...] two constituents intrinsic to the process of negotiation of meaning, and their complementarity reflects the inherent duality of this process.” (Wenger 1998, p. 52). Reification as an activity thus refers to the way of making something real by bringing it into being in concrete ways such as artefacts. It is important to note that the duality of participation and reification is not a distinction between social structures and physical representations. Instead, it suggests that when it comes to meaning-making, people and things cannot be defined independently of each other.

In cooperative work artefacts play an important role, since they potentially take form of reifications in the work. Reification is the objectification of shared knowledge and meaning related to a particular community (Wenger 1998). Often reifications are embodied within artefacts, which pose additional spatial information within the community by embedding certain meaning developed by the community (Wenger 1998). Artefacts often support routines in cooperative work, and therefore exploring the use of artefacts in routine work can assist us in identifying important patterns for how actors balance stability and variation in the common field of work (Feldman and Pentland 2003). By recognizing routines as

a part of the cooperative practices (Esbensen and Bjørn 2014), it becomes possible to consider how generative patterns of the mundane activities become manifested through concrete artefacts and projects. When we study the cooperative practices in the Hackerspace, we thus need to explore processes of participation and reification as they are manifested in artefacts, and in particular their relation to the meaning-making process, which shape the identity of the Hackerspace (Avle and Lindtner 2016). Cooperative work takes place in situations, where multiple actors are mutually dependent in their work (Schmidt and Bannon 1992). This means that individual activities do not only impact the work of individual actors, but also alter the state of the common field thereby thereby impacting others. It is the extra effort of articulation work caused by the mutual dependency, which makes the situation cooperative. In some cooperative engagements there are less strong dependencies also referred to as attachments in work (Dantec and DiSalvo 2013). Attachments characterize the process by which participants develop their identity by being committed to a specific course of action that ultimately challenges the community, which participants depend upon to actually take action. Attachments thus provide an alternative way to theorize about dependencies in cooperative work.

Method

Investigating how identity is produced within an egalitarian grassroots Hackerspace, we conducted an ethnographic study (Randall, Harper et al. 2007) within a Danish Hackerspace over a six-month period between October 2014 and March 2015. CoLab was founded by a group of makers in 2009, who had an interest in creating a hub for hacking and tinkering. The Hackerspace currently has 100-150 active members as well as 700+ members on their e-mail list. The empirical data consists of 119.5 hours of participatory observations and informal interviews in CoLab. Over the course of the study, we did not encounter female participants in the space, but interacted with 37 male participants. While CoLab at this time was male dominated, we chose not to focus on gender ratio as such, but instead on the identity of the space to unpack the cooperative engagement that takes place in the space. Most of the members are between 30 and 50 years old and possess technical and creative skills. In total, 7 researchers took part in the data collection. Collecting data included conversations with the participants concerning projects as well as everyday topics, but also matters of the Hackerspace. During these interactions, we sought to take part in their daily routines as well as reach different types of participants, ranging from founding members to newcomers. In example, we participated in three Tuesday's open house events and once in their regular Thursday meetings, which is where formal decisions are made. Furthermore, we attended an extraordinary general assembly

to further investigate the decision-making processes in the space. We documented all activities through field notes, audio, and photos, which were typed up immediately after the observations.

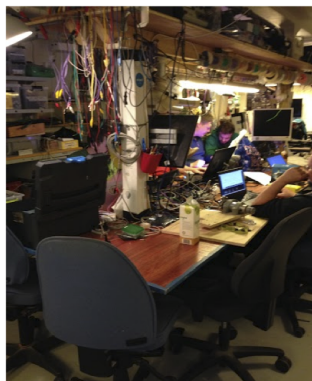
Results

When entering CoLab, a distinctive smell of wood and basement hits your nose and you see a vast number of electronic devices and equipment taking up the space. The Hackerspace is located in a low-ceilinged basement with modest lightning, which makes it feel like a cave. The space consists of eight interconnected rooms organized as a maze (Figure 1).



Figure 1: Floor plan of CoLab

The primary room is Tron Lab (room 4), which holds a large, oblong table surrounded by old, used office chairs. The table is the participants' preferred meeting point. Above the table are ceiling shelves with numerous variants of cords and electronic measuring devices (Picture 2). Along the walls are tall shelving units filled with small widgets, gizmos, and electronic equipment contained in boxes. Amongst these are several unfinished, ongoing projects stored and tagged with the owners' names (Picture 3).



Picture 2: Tron Lab desk



Picture 3: Shelving units

The physical frame and expression of CoLab emphasize how the Hackerspace has developed through years of use, and how the participants' interests and ideas have shaped the functionality of the individual rooms.

Temporal patterns

The routines in CoLab have been developed over the years and are fundamental to the collaborative practices. Two regularly occurring events are the weekly open house and the bi-weekly Thursday meeting. The open house events take place every Tuesday between 7pm and 9pm and are well-attended and buzzing with activity. The purpose of the open house events is to promote the space and acquire new members. Thursday meetings function as the main organizational entity, where important decisions are made. The meetings are hosted every Thursday in odd weeks and begin around 7pm. This is where potential disagreements and issues are resolved and different topics are discussed such as how the space should participate in cultural events like Copenhagen Culture Night. CoLab also has a board of directors, but only because the Hackerspace is subject to the associations act in Denmark, which means that having a board of directors is a mandatory requirement by law. The board of directors does not make any decisions without acceptance from the other members, and this approach is important for the culture. In practice, the Thursday meetings act as the ruling entity for decision-making – or rather consensus-making, since the members of CoLab want to uphold an open organizational structure. This is also why the Hackerspace only has two defined rules: Guideline 0 and Rule 0. The latter of the two demands that participants do not act in a way that would require them to create new rules, and Guideline 0 asserts that membership is free, but to use the Hackerspace you have to add value by participating in projects of maintaining the space by painting the floor, cleaning, or cooking.

Shortening your Google search

A central aspect of the cooperative work within CoLab is characterized by sharing knowledge and expertise. Knowledge sharing is core to the cooperative work in CoLab, and participants explicitly articulate how knowledge sharing is a main part of the space identity. All members of CoLab are expected to contribute by sharing knowledge. One of the founding members, Alex, explains knowledge sharing in CoLab as follows:

“[CoLab is a] place that can shorten your Google search from three hours to three minutes”
(Observation, March 17th 2015)

According to Alex, being part of CoLab provides participants with qualified and detailed access to highly technical information. By comparing the participation in CoLab to a Google search, he explains how Google does not necessarily provide

useful answers to inquiries due to the one-way interaction when searching for answers. It is often in cases where people experience difficulties in phrasing questions that they need the most help. CoLab facilitates such support through interaction, while Google only answers questions that you know how to phrase. The expectation is that all participants in the space remain open and willing to share knowledge and engage in conversation with others. Henrik and Christian explain in more detail:

“The Hackerspace is all about sharing knowledge, which I like a lot: [...] of course we exchange quite a lot of knowledge, and this is actually a characteristic of the space” (Observation, March 11th 2015; Observation, March 18th 2015)

The participants’ ways of sharing knowledge are crucial to the manners in which they interact and collaborate. By being collocated, while working on individual projects, informal knowledge sharing becomes the main interaction in the space. When observing Tron Lab, it was clear that the oblong table enabled participants working on their own projects, to share and help each other out in a highly interactive and communicative way. Whenever someone encounters a problem they articulate it explicitly by asking for help out loud in the room. Often such questions trigger a conversation among the participants and different possible solutions are discussed subsequently turning the topic into more general conversation or initiating new conversations or discussions.

These interactions serve to support the creative construction of knowledge within CoLab in different ways than if participants work on a shared project. The members value interaction and knowledge sharing although they generally encourage newcomers to try solving the problem themselves before asking for help. Several members directly articulate that they do not merely want to serve as a Google search for novices, but instead consider the interactions during discussions among peers as valuable ways of constructing new knowledge. The interplay between obtaining and sharing knowledge is thus very important to the members, and it is central that all involved gain from the interaction.

Do-Not-Hack

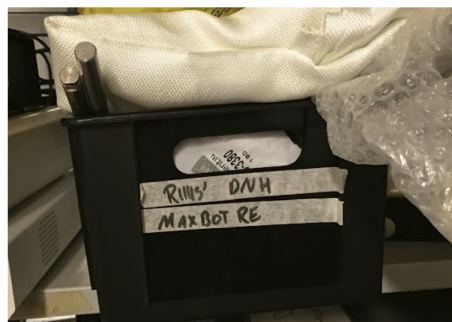
There are many diverse types of expertise gathered in the Hackerspace, e.g. in areas such as constructing 3D printers, soldering, coding, and making circuit boards, just to mention a few. This expert knowledge related to concrete skills and qualifications is an important asset in CoLab, and expertise is often articulated as knowledge about particular tools, devices, and machines. The experts, known as super-users of specific equipment, are made visible for others through practices of labeling. The majority of devices, tools, and equipment in CoLab are labeled with QR codes, which name the tool while providing a way to locate additional information about its functionality (Picture 4). When scanning a QR code, participants are directed to a webpage listing the super-users of the specific device or tool. In this way, newcomers can get information about who to

contact to learn more about how to use a particular device or tool. The fact that CoLab is home for a sizeable group of experts in diverse domains means that it attracts other knowledgeable individuals wanting to participate in the Hackerspace.



Picture 4: QR code on device

The proficiency of constructing knowledge together is also manifested in the Do Not Hack rule (DNH). This rule prescribes everything within the physical boundaries of CoLab to be free to hack by anyone, unless the project or device has a label with the abbreviation DNH on it (Picture 5). Participants recognize the DNH label as a guiding coordination mechanism, since the artefact and its location in particular serve to guide participants to act accordingly towards other's work. Therefore, the DNH label on devices reduces the effort of articulation required for the loosely coupled cooperative work in CoLab.



Picture 5: DNH label

As a novice to CoLab it can be difficult to notice and interpret the meaning of the different labels (QRcode or DNH) and thus act accordingly to the official yet unarticulated organizational structure, which serves as the foundational ground

for the Hackerspace. This leads to difficulties in the organization of cooperative engagement, as some participants fail to follow the organizational structure, and thereby not apply the correct use of the coordinative artefact:

“[...] Jens once left a computer in CoLab that he had to repair for a colleague without putting a DNH label on it. When he returned, both battery and screen were missing and he had to reimburse his colleague.” (Observation, March 4th 2015)

The DNH rule linked to an artefact helps guide and coordinate participants' behavior. However, it is interesting how the labeling of the artefacts does not make a coordinative mechanism by embedding the protocol for work within the artefact. Instead, we saw how the organizational protocols were enacted through artefactual manifestations (the labeled artefact), which required certain skills in interpretation of the common understanding of labeling – as well as the meaning of none-labeling. Clearly, the labeling practices of artefacts are enforced, however the interpretation of the required protocols is not set in stone, therefore causing situations of misunderstanding like in the case of Jens. It can appear drastic that someone would hack Jens' computer just like that, but to the participants this action serves as a completely legitimate practice. To the question of why there are no DNH labels on the tables in Food Lab, Henrik, one of the members, explains:

“[...] it is a common resource and you don't just change something like that.” (Observation, March 11th 2015)

The none-labeling of the tables indicates that the concept of DNH labels stretches beyond the physicality of the label itself. There is thus a common understanding that some items are free to hack while others are not. Through the DNH labels and the concept that stretches beyond these, the participants coordinate and ensure a mutual understanding, where they act accordingly to certain rules of interaction. This mutual understanding strengthens the interactions in the space and therefore supports the construction of knowledge.

Knowledge sharing as social glue

There is a widespread technical know-how and expertise inherent in CoLab that builds upon a common language shared between the participants, which is characteristic for the ways in which they socialize. In order to communicate in the space it is important to share the technical lingo, which often is based on their educational background, but also from constantly keeping up to date on technical discussions on the Internet or by simply continuing to perfect their expertise through practice. Socializing springs from discussions and conversations of technical matters, and therefore knowing and expanding the technical language is required to participate properly in these practices, as it is highly related to the cooperative engagements and identity of the Hackerspace.

Getting to know the language takes time and effort as one of the members, Peter, experienced early when he first joined CoLab. Peter is a magician, and his interest is to develop new tricks for his magic shows using technology. Peter

experienced a clear barrier related to the technical language when he first joined CoLab. He did not know much about technicalities, but he joined the space anyway to get help with one of his technical magic tricks:

“Peter says he found it difficult as a new member to get help sometimes. People would often answer "Google it" when he asked for help if they did not have the patience to explain it to him.” (Observation, March 9th 2015)

Peter explains that if you do not possess technical knowledge it is difficult to receive help from others since, as we saw earlier, the users do not wish to merely function as a Google search, but rather they value the two-way communication in knowledge sharing. Interestingly, our data shows how knowledge sharing and socializing are highly interlinked and can only be divided analytically. Sharing knowledge serves as social glue, and socializing serves as a motivation to engage in knowledge sharing. To contribute to the practice of socializing it is important to have a technical knowledge and to be able to cooperate with other members. In order to learn how to participate, spending time in the space is crucial. The members articulate how they feel highly attached to CoLab:

“Robin says that the Hackerspace is his second home, and Alex answers with a smile: My home is my second Hackerspace.” (Observation, March 3rd 2015)

Several of the participants discuss how their homes resemble the Hackerspace as they keep different artefacts and objects everywhere. However, socializing and building the strong sense of community is important, which is why they choose to spend many hours each week in the space. In this way, the Hackerspace works as a haven for technically skilled individuals; meaning that socializing practices in CoLab supports peaceful tinkering, which also creates a breeding ground for newcomers to gradually perfect their technical language that ultimately enables participation.

DIY-IoT gimmicks

Maintaining and caring for the space are central parts of the activities in CoLab, which include cleaning up after Thursday meetings, as well as sorting boxes, painting the floors, or facilitating the open house events. Maintaining the space is a collaborative task that all members participate in. Even though most of the participants have their own individual projects, they are also part of a larger common project referred to as Project CoLab. In Project CoLab, participants’ interests and ideas are expressed through technical gimmicks and gadgets and exemplify the ways in which the rooms in CoLab are hacked. In example, the participants make several technical hacks, like turning on lamps when the toilet is occupied, while counting the minutes people are in the restroom and displaying the numbers on the wall. Another hack is an old-fashioned landline telephone built into an old phone booth hanging on the wall, which exemplifies an important characteristic of the space:

“There is a large variety of technical gimmicks that the members of CoLab have made

themselves. [...] the small gadgets make the space more fun to be a part of and use [...]“(Observation, February 4th 2015)

While the gimmicks are clearly based upon the participants’ interests and gadgets they find entertaining, other activities also characterize the Hackerspace. In example, repairing and cleaning up after the space was flooded due to a thunderstorm, is seen as part of Project CoLab. Other activities are more repetitive, such as emptying recycling bins, buying utilities, such as soap and toilet paper, and filling up the shared fridge with drinks and snacks each week. It is considered a substantial part of maintaining the space to continuously care for CoLab and keep the physical surroundings intact and up to date with new technical features. Since the participants invest a great deal of their time in the space, they take part in shaping its identity.

As part of Project CoLab three of the members, Henrik, Mikkel, and N. Clausen, collaborate on an electric backdoor for entering the Hackerspace. The front door of CoLab has an automatic door opener, which allows participants to enter with a card and the members also want similar functionality on the back door. To solve this task, they decide to split up the project into smaller sub-tasks to be executed by participants with the necessary skills and expertise. Mikkel is in charge of the design work, where Henrik is responsible for hammering and drilling activities, while N. Clausen write the required the code. When participating in such a joint project, the members shape the Hackerspace towards desired values of creativity and social community. It is interesting to note that they rarely set deadlines for joint projects in Project CoLab, as seen with the backdoor. Projects are not to be finished within a certain timeframe; instead participants work on the projects when it is convenient. Acknowledging each other’s talents, expertise, and skills is key, as it also encourages contribution to shaping the space:

“Henrik explains that Mikkel is very meticulous and that he would not have bothered doing a test-print for the door himself [...] Henrik believes that cooperation works well because projects become better prepared and planned”. (Observation, March 9th 2015)

Project CoLab is a dynamic manifestation of the identity of the space and the characteristics of the type of collaborative practices participants wish to encourage. Projects that help maintain the Hackerspace create a sense of community as teamwork and collaboration make participants feel as part of something larger.

Freedom of Negotiation

The majority of the Hackerspace’s financial support comes from monthly fees paid by the participants. Fees are kept low to ensure that participants with little income can still join. If members do not have the financial resources to pay the fee, they are still welcome and can contribute in other ways by making food, cleaning, or helping with similar chores as these activities are equally appreciated

in CoLab. The freedom to participate independently of income is thus an important characteristic of the Hackerspace's identity. Another significant part of the Hackerspaces' identity is the members' insistence on having a decentralized organizational structure, which allows frequent open-ended discussions among all members. All who participate take part in evaluating and discussing the current situation and make decisions concerning potential changes in CoLab. During our study, we encountered multiple instances, where participants continuously negotiated the organization and its structure. In example, during one of the board meetings, the conversation moves from discussing topics on the agenda to questioning the very role of the board itself. A member, Mikkel, makes a comment:

“He thinks that the term ‘board of directors’ has a negative ring to it, and it does not necessarily need to be a ‘board of directors’ as such. Mikkel thinks that it is naive to believe that CoLab can function without anyone being able to make quick decisions” (Observation, March 14th 2015)

The continuous discussions of the organizational structure in CoLab are frequent within the space, not only during board meetings, but also in general. Often, discussions of topics are initiated and continued even if they are not on the agenda. Interestingly, the cooperative practices in CoLab demonstrate how preserving the freedom to debate the organizational structure of the space at all times is critical for the identity of the Hackerspace. Members spend a lot of time on these discussions even if it interrupts the agenda for a meeting.

In the everyday interaction the consequences of the open-ended organizational structure are opaque and blend into the background. However, the egalitarian nature of the space also causes problems, which becomes evident when conflicts between participants arise. Conflicts causing the members to create additional formal rules and policies are rare, but we encountered one episode that clearly illustrated how the members deal with conflicts. A small group of members wanted to allow investors to finance new facilities and expand the community with a substantial number of new members. They were hoping to gain funding and commercialize an open-source product, which they built in the space. However, this change would risk making the outside investors part of the board of directors. Existing members were anxious about how such changes would affect the community. This was the core disagreement, as Henrik, one of the involved members explains:

“[...] a Hackerspace must be a haven for those who are conflict-averse. It is therefore important for members of the community not to be trumped by new members and thereby lose the community [...]. (Observation, March 9th 2015)

When conflicts arise, the Hackerspace becomes very fragile, as the members do not have the necessary tools to handle conflicts according to themselves. The choice to either include or exclude investors, who could transform the identity of the community in critical ways, could lead to radical changes in the community's values and principles. Usually, the participants strive to reach consensus when

experiencing conflicts and disagreements. They use the Thursday meetings to discuss and negotiate conflicts, and it is a joint responsibility to develop the organizational structure in the space. However, in conflicts like the example above it is challenging to arrive at a definitive decision when having a decentralized organizational structure. This example indicates that the freedom of negotiation is contingent on an overall agreement that CoLab is not guided or affiliated with formal institutions or organizations, why some topics in reality remain non-negotiable. Most of the discussions are open-ended and interestingly, the point of the discussions is not necessarily to support decision-making. Rather, the discussions are motivated by a continuous effort between the participants to collaboratively develop CoLab as an organization. The fact that CoLab only has a board out of legal necessity emphasizes how the role of the board is constantly up for debate. They are eager to discuss the organizational structure, but reluctant to formalize. Their insistence on keeping a decentralized organizational structure with a board with no resoluteness is a protected characteristic for the space. Clearly, keeping the current culture based upon the open-discussions and a minimum of formal rules is hugely important. As Henrik explains:

"[...] CoLab is fragile as a community. It doesn't take much to ruin the dynamic that exists and we therefore try to protect the place. It is important that there is some acceptance of norms and policies that shows respect and tolerance towards others." (Observation, March 9th 2015)

The identity of CoLab is not characterized by any formal guidelines. Instead, the structure preserves freedom of negotiation by not formalizing the Hackerspace, and thereby securing the existing values and principles of the community. Interestingly, this is not only practiced during the formal meetings such as the board meeting. Instead, it is closely interlinked with knowledge sharing, socializing and caring for as well as innovating the space, as debate and discussions on how to develop the Hackerspace takes place continuously across all these activities.

Discussion

The cooperative identity in CoLab is primarily constituted by two intertwined activities. The first activity is the ways in which the participants hack the physical surroundings through technical gimmicks on e.g. doors and refrigerators. The hacks are highly valued by the community and help participants demonstrate their technical skills and competences through imagination and participation. The hacks are constituted in technical gadgets, which transform into reifications (Wenger 1998) for how the cooperation is organized and structured e.g. as seen with the DNH labeling. Here, the members of CoLab manifest their rules through tangible artefacts, and the artefacts thus play a central role in shaping the identity of CoLab. The different artefacts also provide a foundation for cooperation in the space, but it is interesting how it is not the technical gadgets or artefacts as single

entities that are important, but rather the relations and infrastructure created across these artefacts that are central for the collaborative activities. The relational infrastructure of the different artefacts transforms the physical facilities within the Hackerspace into one shared DIY-IoT entity consisting of multiple smaller projects. The physical facilities of the Hackerspace are turned into an ecology of artefacts, which guides the collaboration between members. Participants, who regularly spend time in CoLab develop mutual interpretations and related meanings of the ecology of artefacts, and the physical facilities therefore become a manifestation of the cooperative nature of CoLab through reifications (Lave and Wenger 1991). Infrastructuring the Hackerspace is an essential vehicle in shaping innovation and making (Ahmed, Mim et al. 2015, Stickel, Hornung et al. 2015) and the interrelation between the social organization of work (e.g. knowledge sharing) and the physical manifestation of the joint projects (hacking the space) co-constructs the identity of CoLab.

The second activity constitutive for the cooperative identity in CoLab is the ways in which participants re-negotiate the structure and organization of the cooperative engagement in the space e.g. during Thursday meetings, open house events, or when managing conflicts. The constant insistence on keeping a decentralized organizational structure in CoLab requires ongoing attention to negotiating meaning through participation and reification. The open-ended structure enables cooperation and makes it possible for the participants to develop the cooperative identity (Avle and Lindtner 2016) of the space. This means that the identity of CoLab is continuously being interpreted and negotiated through routinely practices. We found that the artefacts within the Hackerspace form manifestations of the organizational structure through reifications for practice (as we saw with the categories DNH label or none-labeling), rather than fixed coordinative mechanisms (Schmidt and Simone 1996) with embedded protocols. If the artefacts were functioning as coordinative mechanisms, they would possess an explicit unequivocal meaning, but in CoLab this is not the case. Artefacts in CoLab are continually being interpreted and negotiated through several routine practices, and it is in these practices that the meaning of artefacts emerge as reifications for the cooperative work. The interpretation of reified artefacts is continuously being developed and they never become formal objects with clearly defined protocols. Instead, the structure and protocols are changed accordingly to match the cooperative identity of the Hackerspace. This demonstrates how the intertwined practices of social and material production both produce and preserve the identity of the Hackerspace. To some extent, all Hackerspaces have unique features – and CoLab is no different. It requires interpretation work and insider knowledge to understand the intention with the reified artefacts, and negotiating the meaning of these artefacts is a fundamental part of CoLab's organizational structure.

It is not only social and material production that evolves through one another,

but also the production and preservation of the cooperative identity. The cooperative identity of CoLab is produced through the participants' commitments to the space. Participants perform productive attachments (Dantec and DiSalvo 2013) to CoLab by on one hand transforming the space through re-negotiation and innovation, while on the other hand being dependent upon the structure to be able to take action and do hacking. The cooperative nature of the Hackerspace is based upon these productive attachments, which drive constant iteration leading to new configurations of the relations between the people, artefacts, and the physical space. The practices create flexible and dynamic cooperative structures, where dependencies in work do not rely upon the work task, but rather on the dynamics between hacking and re-negotiation. Interestingly, these practices do not only produce the identity, but also help preserve it. While subscribing to values characterized by the associations act in Denmark such as being open towards new participants and their beliefs, the participants simultaneously expressed a need to preserve the Hackerspace and its identity. In this way, the activities of hacking and re-negotiating both produce and preserve the identity of CoLab and serve as both inclusive and exclusive mechanisms of the space.

Conclusion

The cooperative identity of the Hackerspace is produced and preserved through the participants' demonstrations of commitment to the space reflected in the continuous hacking of the physical surroundings and constant re-negotiation of the cooperative characteristics. The appropriation of technical competences through the joint transformation of the physical facilities is not simply about improving the physical surroundings, but also includes the essential work of establishing the cooperative identity of CoLab. The participants' collaborative engagement is structured and guided by their hacking activities of the physical surroundings, which are instrumental in producing the identity of the Hackerspace. Maintenance and repair work are inherent parts of the collaborative work transforming not just the tools, but also the entire space to preserve the existence and identity of the Hackerspace. Furthermore, the continued re-negotiation of the cooperative characteristics is part of shaping the identity of the space. The implicit rules and policies of the space are critical to preserve the fragile identity of CoLab. While the work of demonstrating commitment by innovating the physical surroundings and re-negotiating the cooperative characteristics appears as 'behind the scene' work – the invisible work – it is truly these cooperative practices, which are central in both producing and preserving the identity of the Hackerspace.

Acknowledgments

We want to thank the participants from CoLab for welcoming us. Furthermore, we want to acknowledge Lærke Elmén Pedersen, Sofie Amalie Anker, and Tina Cecilie Schultz, who took part in the data collection.

References

- Ahmed, S. I., N. J. Mim and S. Jackson (2015). Residual mobilities: Infrastructural displacement and post-colonial computing in Bangladesh. CHI'15. Seoul, Korea, ACM: 437-446.
- Ames, M., J. Bardzell, S. Bardzell, S. Lindtner, D. Mellis and D. Rosner (2014). Making cultures: Empowerment, participation, and democracy - or not? Panel: CHI: One of a CHInd. Toronto, Canada, ACM.
- Avle, S. and S. Lindtner (2016). Design(ing) 'here' and 'there': Tech entrepreneurs, global markets, and reflexivity in design processes. CHI. San Jose, CA, USA, ACM: 2233-2245.
- Bardzell, J., S. Bardzell and A. Toombs (2014). Now that's definitely a proper hack: Self-made Tools in Hackerspaces. CHI Toronto, Ontario, Canada, ACM: 473-476.
- Dantec, C. L. and C. DiSalvo (2013). "Infrastructuring and the formation of publics in participatory design." Social Studies of Science **43**(2): 241-264.
- Esbensen, M. and P. Bjørn (2014). Routine and standardization in Global software development. GROUP. Sanible Island, Florida, USA, ACM.
- Feldman, M. and B. Pentland (2003). "Reconceptualizing organizational routines as a source of flexibility and change." Administrative Science Quarterly **48**: 94-118.
- Fox, S., R. Ulgado and D. Rosner (2015). Hacking culture, not devices: Access and recognition in feminist hackerspaces. CSCW. Vancouver, BC, Canada, ACM.
- Fuchsberger, V., M. Murer, M. Tscheligi, S. Lindtner, S. Bardzell, J. Bardzell, A. Reiter and P. Bjorn (2016). Fabrication & HCI: Hobbyist Making, Industrial Production, and Beyond. Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. San Jose, California, USA, ACM: 3550-3557.
- Lave, J. and E. Wenger (1991). Situated learning: Legitimate peripheral participation, Cambridge University press.
- Lindtner, S., G. Hertz and P. Dourish (2014). Emerging sites of HCI Innovation: Hackerspaces, Hardware Startups & Incubators. CHI. Toronto, Canada, ACM.
- Moilanen, J. (2012). Emerging hackerspaces - Peer-production generation. IFIP, OSS, AICT 378. I. H. e. al., Springer: 94-111.
- Randall, D., R. Harper and M. Rouncefield (2007). Fieldwork for design: Theory and practice. London, Springer.
- Schmidt, K. and L. Bannon (1992). "Taking CSCW Seriously: Supporting Articulation Work." Computer Supported Cooperative Work (CSCW): An International Journal **1**(1-2): 7-40.
- Schmidt, K. and C. Simone (1996). "Coordination Mechanisms: Towards a Conceptual Foundation of CSCW System Design." Computer Supported Cooperative Work (CSCW): An International Journal **5**: 155-200.
- Stickel, O., D. Hornung, K. Aal, M. Rohde and V. Wulf (2015). 3D printing with marginalized children - An exploration in a Palestinian refugee camp. European Conference on Computer Supported Cooperative Work (ECSCW). Oslo, Norway, Springer.

- Sun, Y., S. Lindtner, X. Ding, T. Lu and N. Gu (2015). Reliving the past & making a harmonious society today: A study of elderly electronic hackers in China. CSCW. Vancouver, BC, Canada, ACM.
- Taylor, N., U. Hurley and P. Connolly (2016). Making community: The wider role of makerspaces in public life. CHI. San Jose, CA, USA, ACM: 1415-1425.
- Wakkary, R., M. L. Schilling, M. Dalton, S. Hauser, A. Desjardins, X. Zhang and H. Lin (2015). Tutorial authorship and hybrid designers: The Joy (and Frustration) of DIY tutorials. CHI 2015. Seoul, Korea, ACM: 609-618.
- Wang, T. and J. Kaye (2011). Inventive leisure practices: Understanding hacking communities as sites of sharing and innovation. CHI. Vancouver, BC, Canada, ACM: 263-272.
- Weibert, A., A. Marshall, K. Aal, K. Schubert and J. Rode (2014). Sewing interest in E-textiles: Analyzing making from a gendered perspective. DIS. Vancouver, BS.
- Wenger, E. (1998). Communities of Practice: Learning, Meaning, and Identity. Cambridge, Cambridge University Press.