Technological Foundations for Long-Term HCI Research: A Case for Simplicity

KLAUS STEPHAN, Chemnitz University of Technology, Germany

To understand the long-term effects of new technologies, long-term deployments of design artifacts are a crucial part of Human-Computer Interaction (HCI) research. Only long-term studies can reveal the effects of habituation and how routines form around design artifacts. Unfortunately, they are relatively rare and replication studies are even rarer. This paper argues, that this is due to a lack of focus on simple, robust and inexpensive solutions that would foster replicability and build a shared foundation. To open a dialogue abound creating a shared foundation for long-term deployments, a set of principles is proposed that include openness, simplicity, robustness and affordability. This shared foundation is meant to facilitate comparison, replication studies and refinement of design artifacts over multiple projects and institutions. This will ultimately increase our understanding of long-term effects of human-technology interaction by allowing for numerous and successful long-term deployments of design artifacts.

CCS Concepts: • **Human-centered computing → Human computer interaction (HCI)**.

Additional Key Words and Phrases: normalization, mapping functions, multisensory, multimodal, design, ideation, tools, methods, IoT, Internet of Things, tangible interactive devices, input and output devices, tangibles

1 Introduction

For researchers in Human-Computer Interaction (HCI), the importance of understanding the long-term effects of the interactions of humans and technology is an important field of study. While short-term deployments of artifacts, typically lasting from a few days to a few weeks, can provide valuable insights into acceptance, initial user experiences, usability issues and the effectivenes of novel interfaces, the perception of technology can change drastically after the initial curiosity and novelty wears off. Long-term studies, which can last from several months to years, give insight into habituation, how users form routines and habits around the deployed artifacts, how they experience benefits and drawbacks over time and how their well-being is affected. Despite the benefits of such long-term deployments, they are relatively rare in HCI research and replication studies are even rarer. This can be improved by opening a discussion about a solid, affordable, shared and replicable technological foundation for long-term deployments and design artifacts in general.

The Morse Things [7] and Yo-Yo Machines [3] projects will be used as examples to illustrate different approaches to designing technological foundations for long-term deployments. These cases will highlight the benefits and drawbacks of each approach, including the trade-offs between using easily procured maker components and using specialized technologies, and demonstrate the importance of considering these factors in the development of technological foundations for long-term deployments.

Author's Contact Information: Klaus Stephan, Chemnitz University of Technology, Germany, klaus.stephan@informatik.tu-chemnitz.de.

Manuscript submitted to ACM

2 CaseStudy

A notable example of simple, robust, and replicable artifacts for long-term deployments is the Yo-Yo Machines project by Gaver et al. [3] [5]. The Yo-Yo Machines are a series of interactive devices designed to explore the potential of everyday objects as interfaces. What makes this project particularly noteworthy is the highly accessible and open-source nature of the artifacts, which are made from inexpensive and readily available parts. The researchers have made available a comprehensive build guide, software images, and a web service for communication, allowing others to easily replicate and build upon their work. By releasing all software components as open-source repositories, the project facilitates collaboration, promotes transparency, and enables future researchers to directly build upon the existing foundation. It has to be said, that there is a history of of working towards the simple elegant design that is shown in the Yo-Yo Machines paper, the previous projects ProbeTools [1] and My Naturewatch Camera [4] are not as easy to make. This shows that getting to the point where designs are easily replicable is a considerable investment and may take up a part of the project resources. The example of the Yo-Yo Machines exemplifies the principles of simplicity, robustness, and replicability that are one of the avenues to enabling long-term-deployments by making the devices available to a large number of researchers who can use them in studies. If that works out to enable other researchers to do more studies and long-term deployments, the additional effort is well worth it.

Another notable example are the Morse Things developed by Wakkary et al. [7], but for different reasons. While it is an excellent long-term study that gives profound insight into habituation and the long-term effects of the artifacts on humans, it is unlikely that the study will be widely replicated because the artifacts are hard to replicate. The Morse Things are ceramic bowls and cups with embedded electronics, which require specialized knowledge and technology to replicate. While the paper contains an overview of the technology, it doesn't aid in the replication of the artifacts beyond a general outline. So while the study is a success in itself, it doesn't lend itself to new long-term deployments due to the difficulty of recreating the artifacts used.

Those two examples outline two opposite approaches to long-term deployments.

The Yo-Yo Machines were always designed with the goal of making them replicable and affordable, so that other researchers and the public can build the devices and use them. While it is hard to get feedback from the public, other researchers using the devices for their studies is much more likely to get published results about deployments. This approach goes wide to increase the chances of getting long-term deployments along with other feedback.

The approach of the Morse Things is clearly to focus on the resarch questions and build high quality artifacts that don't distract from their intended effects by looking poorly made or malfunctioning. Using ceramics to embed the electronics instead of using plastic cups and bowls allowed them to seamlessly integrate into the existing tableware. The quality of the artifacts was clearly prioritized over ease of replication, which is a reasonable approach to get good results from a study. It is hard to recruit participants for long-term studies, so focusing on getting the most out of the deployment over other concerns is reasonable.

While these two cases show the ends of the spectrum with the simple, affordable and replicable design of the Yo-Yo Machines and artifacts that require specialized technology but fit in easily with industrial goods due to their quality on the other end of the spectrum with the Morse Things, there are many design artifacts that are somewhere in between and represent a middle ground.

3 Discussion

Considering the goal of enabling more long-term deployments of design artifacts in the light of examples presented in the case study, we can outline some design priciples that would aid in that goal and discuss the implications.

Openness: Most of the design artifacts generated in the HCI community are well documented in terms of describing the design idea and process, functionality and the studies done with them. Unfortunately, not all of the software used is provided as open source repositories and the detail on the building of the hardware widely varies.

Even if it means additional work, refining processes to the degree that they can be used as an actual build guide and cleaning up code so that it is useful as open source repository makes it much easier for other researchers to build on existing projects without redoing a lot of the work.

Simplicity: Complex design artifacts with a lot of new ideas,functionalities and technologies can be very inspirational, especially when they are of high quality make. On the other hand, it makes their recreation really hard. Even if we aim for simplicity, a elegant simple solution usually is the end of a long design process and iterations, not the starting point. Still, it is worthwile to strive for simplicity, as it aids in creating good documentation and build guides that can be the starting point of new research.

Affordability: Ideally, recreating the artifacts would be in the budget of students for a bachelor or master thesis to get the widest possible audience. If the artifacts are customizable, we can also think about doing workshops to recruit participants for long term studies, here the cost has to be low enough to justify giving the parts away because they might not be salvagable afterwards. This puts even quite affordable consumer hardware like the PoGo rinter used in the PhotoBox in Odom et al.'s Intersecting with Unaware Objects paper[6] or the android tablet used in Bereton et al.'s Messaging Kettle [2] over the margin where the artifacts will see a lot of replication. It would be preferable to aim for a minimal selection of affordable maker parts.

Robustness: For long-term deployments, artifacts have to be robust enough to survive the deployment and not make problems that distract from the goal of the study. This is an argument for using consumer hardware like the printer or tablet discussed above, but it can also be achieved by using a simple design made from affordable maker components. Simplicity of the design ensures repairability and allows for further refinement that increases robustness, it also means that the artifacts are replaceble because of the low cost.

All those principles are well known, but if we look at them in the light of long-term deployments and the problems of the usual project and funding cycles, they become especially important and warrant discussion.

The paper touched on two avenues to more long-term deployments: Going wide and spreading the artifacts through build guides and open source and building projects upon each other. Both approaches benefit from those principles, just to different degree.

For the first approach, having easily replicable artifacts that adhere to all those principles is crucial. To enable a wider audience of reserchers and the public to build the devices, they have to be open source, include a build guide and be affordable.

For the second approach, everything that a project can offer to enable follow up projects is valuable. Projects focusing on long-term deployments would benefit greatly from build guides and open source software that enables them to build their deployments faster and focus on recruitment of participants for the actual long-term study.

Finally, using simple artifacts for long-term deployments on a large scale and througout multiple projects might benefit from the recent advancements of Large Language Models (LLM) to evaluate user reports at a scale that was previously not feasible. In addition, focusing on simple devices that produce logs in the form of simple time series data that can be easily anonymized may lend itself to building larger data sets that can be analyzed using machine learning techniques. Those efforts may also benefit from coordinating what technologies and infrastructure are used across institutions and projects to generate datasets that are compatible and can be evaluated together in meta studies.

Overall, looking at the technological foundation, looking for ways to share knowledge and synergize efforts, seems worthwhile at the current point in time, both to adress the challenges and opportunities that come with the recent developments in AI as well as taking stock of recent projects and what we can learn from them for the path forward.

4 Conclusion

For furthering the goal to understand the long-term effects of technology through long-term deployments, it is worthwhile to take a good look at the foundations, both the technological foundation as well as the design principles that we follow. Pointing out the importance of openness, simplicity, robustness and affordability as guiding principles to enable new projects and increase the number of long-term deployments, we should take a look at recent projects and their outcomes and plan a path forward. The recent advancements in AI technology offer opportunities to evaluate larger datasets, but to make use of those opportunities we have to meet the challenge of scaling up the size and number of long-term studies and synergizing the efforts to create compatible datasets that can be used together.

References

[1] Andy Boucher, Dean Brown, Bill Gaver, Naho Matsuda, Liliana Ovalle, Andy Sheen, and Michail Vanis. 2019. ProbeTools: unconventional cameras and audio devices for user research. *Interactions* 26, 2 (Feb. 2019), 26–35. doi:10.1145/3305358

[2] Margot Brereton, Alessandro Soro, Kate Vaisutis, and Paul Roe. 2015. The Messaging Kettle: Prototyping Connection over a Distance between Adult Children and Older Parents. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI '15)*. Association for Computing Machinery, New York, NY, USA, 713–716. doi:10.1145/2702123.2702462

[3] William Gaver, Andy Boucher, Dean Brown, David Chatting, Naho Matsuda, Liliana Ovalle, Andy Sheen, and Michail Vanis. 2022. Yo–Yo Machines: Self-Build Devices that Support Social Connections During the Pandemic. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 458, 17 pages. doi:10.1145/3491102.3517547

[4] William Gaver, Andy Boucher, Michail Vanis, Andy Sheen, Dean Brown, Liliana Ovalle, Naho Matsuda, Amina Abbas-Nazari, and Robert Phillips. 2019. My Naturewatch Camera: Disseminating Practice Research with a Cheap and Easy DIY Design. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. doi:10.1145/3290605.3300532

[5] William Gaver and Frances Gaver. 2023. Living with Light Touch: An Autoethnography of a Simple Communication Device in Long-Term Use. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 633, 14 pages. doi:10.1145/3544548.3580807

[6] William Odom and Ron Wakkary. 2015. Intersecting with Unaware Objects. In *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition* (Glasgow, United Kingdom) *(CC '15)*. Association for Computing Machinery, New York, NY, USA, 33–42. doi:10.1145/2757226.2757240

[7] Ron Wakkary, Doenja Oogjes, Sabrina Hauser, Henry Lin, Cheng Cao, Leo Ma, and Tijs Duel. 2017. Morse Things: A Design Inquiry into the Gap Between Things and Us. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (Edinburgh, United Kingdom) *(DIS '17)*. Association for Computing Machinery, New York, NY, USA, 503–514. doi:10.1145/3064663.3064734