The Impact of Low-tech Systems on User Experience: First Methodological Reflections around the Urban Biosphere Experiment

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ABSTRACT

The low-tech approach questions our relationship to technology by challenging notions of need, comfort, and autonomy. By designing useful, simple, and sustainable systems, people involved in the low-tech approach push for a reduction in technology complexity, the empowerment of users, and the idea of sobriety. In this work-in-progress, we present our methodology to investigate the user experience (UX) resulting from the use of low-tech systems. We use the Urban Biosphere participatory experiment as a use case to challenge the traditional view of UX design on notion like efficiency and comfort, and to unveil the challenges and opportunities brought by low-tech innovation approaches for user experience designers willing to engage into strong sustainable practices. The goal is to identify leverage points that can be addressed through design to disseminate low-tech solutions more widely and improve their acceptance and adoption.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

low-tech, user experience, participatory design, sustainability

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1 INTRODUCTION AND RELATED WORK

In 1972, researchers at the Massachusetts Institute of Technology (MIT) published a report on the limits to growth in a finite world [25]. Awareness of environmental problems has since led to new design models focused on sustainability [8, 13, 22]. However, these models often lean towards "high-tech" solutions, limited to reducing the environmental impact of existing products, rather than designing new products and services incorporating sustainability principles [4]. In a world facing an energy constraint, the vision of a more frugal lifestyle starts to resonate with society [18]. The "Transition(s) 2050" study by ADEME [2] explores four paths to carbon neutrality by 2050. "Frugal Generation", the first prospective scenario, is based on a profound change in lifestyles and a production system partly founded on the "low-tech" (LT) innovation approach. The Low-tech Lab (lowtechlab.org) describes LT as "objects, systems, techniques, services and know-how, practices, lifestyles and currents of thought, which integrate technology according to three main principles: utility, accessibility, durability". These widely accepted criteria seem insufficient yet to cover all facets of LT. Besides authors defining LT according to criteria or principles [10, 37], others see it more as "an approach and not its result. Thus, an object is not *"low tech"* in the absolute, it is more (or less) *low tech* than an alternative solution meeting the initial need" [3].

Rooted in techno-critical philosophy, the LT approach questions our relationship to technology and our modes of production and consumption through the implementation of sobriety principles and the development of autonomy. LT practitioners call for the reduction of complexity and the re-politicization of technology through the design of simple and sustainable systems that play with environmental, material, and energy constraints. While entrepreneurial, associative, and scientific initiatives emerge [7, 10, 37], LT remains marginal in the industrial landscape and struggles to appeal to a mainstream audience. We position that one key to general acceptance of LT systems is better experience design, which also serves as an opportunity to unveil a new paradigm for User Experience (UX) researchers and practitioners willing to engage in strong sustainability practices. To address this challenge, we introduce the principles of the LT approach and articulate key questions that researchers and practitioners can use to position their future research on LT design. We illustrate and contribute initial insights into these questions through the methodology of the “Urban Biosphere” participatory study. In this project, we aim to gain insight into how LT systems challenge the notion of user experience, with

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environmental sobriety and user autonomy at its core. The final goal is to support practitioners in designing sustainable systems and participate in the democratization of a strong sustainable LT alternative.

1.1 Low-tech and Sobriety: An Alternative Approach to Needs and Comfort

The concept of "need" is central in the LT approach, which challenges it as "what is sufficient for us to collectively blossom in an ecologically constrained world" [29]. The goal is to reduce the impact of our routines by implementing the sobriety principles into daily behaviors. Routines are strongly related to the characteristics of technology; thus, the design of an LT may change routines by introducing (or removing) features that support eco-behaviors. For example, a solar oven would force users to adapt their cooking habits and recipes to solar energy [24]. For this reason, LT systems can be described as "user-intensive" [10]: the user invests more time or effort to fulfill a need with an LT than with a traditional, non-frugal product. The LT innovation approach thus aims to involve the user more, reduce the level of automation, and question the notion of comfort. It offers to "pay attention to the relevant level of technical intensity needed for a given use case" [10]. This challenges the dominant view of UX design, which often relies on increasing automation to achieve "convenient, clean, and efficient interactions" [17]. Automation is pervasive in every aspect of our lives, pushing users out of the activity for the sake of convenience (e.g., smart homes, autonomous vehicles, automatic coffee grinders). Studies however show that the over-reliance on automation and technological complexity can lead to a loss of enjoyable experiences and meaningful experiences, and thus decrease the feeling of autonomy and competence [21]. The LT innovation approach proposes considering the "experiential cost" of technological complexity (or the level of reliance on technology) to fulfill a specific need in order to reduce environmental impact and user alienation. This is in line with the principles of "Slow Design" [36], which aim to support more activity time for meaningful interaction and less for the non meaningful ones [15].

1.2 Low-tech and Autonomy: the Relation to User Experience

LT was initially assimilated with the Do It Yourself (DIY) movement, as an approach that puts the principles of autonomy into practice through simple objects easily appropriated by users, enabling them to take greater control of their technical environment. The idea is that if the user can conceive, construct, assemble, modify, hack, maintain, repair, or recycle their product, they will make it last longer [37], and reduce its environmental footprint. This is backed up by work on "emotionally durable design" (EDD) [9], which investigated user's emotional attachment to products to reduce consumption and waste: "when a person becomes attached to an object, he or she is more likely to handle the object with care, repair it when it breaks, and postpone its replacement as long as possible" [33]. Ceschin and Gaziulusoy [8] compiled design guidelines for EDD, and a few echoes to the LT concept of appropriation: Involving the user in personalization, customization, and co-design activities; Involving the user in finishing or making (parts of) the product; Designing adaptable products; Involving the user in do-it-yourself repair activities. In consumer psychology, prior work on the "Ikea Effect" resonate with the positive effects of the appropriation of LT systems. Norton et al. [26] investigated through lab experiments the valuation of self-made utilitarian and hedonic products. They found that "labor leads to love", with participants expressing a more positive value judgment for products they had constructed themselves. Self-assembly of products allows people to feel competent and to display evidence of that competence, enabling them to express desired attributes about themselves [12]. This lead to positive effects on the fulfilment of the psychological needs of competence and autonomy, and thus on well-being [30]. Moreover, the fulfillment of these needs is deeply interlinked with the construction of event-related positive affects [35], to the development of a positive UX [16] and thus is a determinant in successful technology adoption [28]. In other disciplines, several studies have investigated LT, focusing on technical aspects [1], philosophical reflections [14], or the implementation of LT solutions in certain contexts [11]. Nevertheless, LT products remain marginal in the industrial landscape and struggles to appeal to a mainstream audience. The HCI and design communities can thus make significant contributions to LT by focusing on the human aspect through the facilitation of user product appropriation and the acceptance of frugal technology-related routines. Colin and Martin [10] assessed with a questionnaire the perceptions of potential problems and the anticipated UX of eight LT artifacts. They found 14 categories of issues related to LT systems and formulated design principles to guide practitioners willing to engage with LT. Nevertheless, no study has examined how the actual use of appropriable and user-intensive LT products impacts the temporal evolution of UX [19], and their adoption. To address this gap, we articulate the challenges of LT adoption through a reflection on the methodology of the "Urban Biosphere" participatory study.

2 RESEARCH OBJECTIVES

After introducing the principles of the LT approach, this contribution aims to articulate key questions that researchers and practitioners can use to position their future research on LT design. In the following, we illustrate and provide initial insights into these questions through the description of the "Urban Biosphere" participatory study and underlying methodological reflections. From our review of current knowledge and obstacles in the adoption of LT, we propose the following questions:

- What are the experience costs and benefits associated with user-intensive LT systems?
- Why does the user remain engaged in a system that is potentially less comfortable or less efficient than the usual way of satisfying his need? Which UX factors significantly impact the adoption of low-tech systems?
- From a design perspective, how to define the right balance between technological complexity and user solicitations? What levers can be used to promote wider dissemination and technological adoption of LT systems?
- How to conduct research aligned with the LT philosophy, and foster participant and researcher mutual empowerment?

Table 1: Description and initial number of participants for the 8 missions of the Urban Biosphere Experiment

Mission	Description	N
Participatory farm	Every week, a group of local friends or colleagues get together to work the land for half a day on a local organic farm. Participants leave with a freshly picked harvest.	17
Bioponic tank	Plant roots are immersed in a simple DIY closed-circuit basin of water and organic fertilizer. This system makes young, vitamin-rich plants - usually expensive - accessible, and to enable longer storage while using 10 times less water than soil-based cultivation.	267
Vegetarian menu	Participants will follow daily recipes from a vegetarian, organic, and seasonal chef menu that best meets daily nutritional needs while being economical and generating no waste.	320
Fog shower	A mist shower that uses 5L of water and combines well-being and water savings: the misty atmosphere is created by nozzles, replacing the shower head.	299
Cricket breeding	Participants will breed domestic crickets, nutritional bombshells with excellent nutritional content while emitting less greenhouse gases than meat production.	81
Oyster mushroom cultivation	Oyster mushrooms transform cellular waste such as straw and wood into nutrient-rich food. Despite their nutritional potential and exquisite flavor, oyster mushrooms remain financially unaffordable for many. This can be overcome by growing these mushrooms from a mixture of granular mycelium and straw pellets. After a one-month incubation phase, the kit will deliver a loaf of mycelium white and ready to fruit.	346
Black soldier fly (BSF) larvae for compost	While mostly thrown away, organic kitchen waste contains valuable nutrients that can be recycled to fertilize the soil and nourish plants. Participants will experience their conversion by BSF larvae. By decomposing the shredded waste, the larvae produce hyper-nutritious compost for the soil in record time. Once adult, the larvae can be used as poultry feed, and the compost can be used in gardens or agricultural fields.	66
Dry toilets waste valorization	Participants will set up and experiment with dry toilets including separators to facilitate human waste valorization thanks to the action of black soldier fly larvae. By decomposing this waste, the larvae produce high-quality compost in record time. Once adult, the larvae can be used as poultry feed, and the compost can be used in gardens or agricultural land.	71

3 THE URBAN BIOSPHERE PARTICIPATORY STUDY

The Urban Biosphere experiment *(www.biosphere-experience.org)* invites citizens to engage in a 4-month LT participatory study. The study is designed to ensure meaningful engagement, mutual learning, capacity building, and impactful outcomes for scientists and participants, which follows the low-tech philosophy. Volunteers recruited through the project's social media signed up for one or several of the eight LT missions proposed (Table 1). Each mission is related to a low-tech system, chosen - based on insights from previous experiments - for its high potential to reduce the environmental footprint of daily behaviors and its ease of implementation in an urban environment. 1467 participants (865 women, 581 men, 21 other) were selected. Participants were moderately familiar with LT (514 novices; 903 intermediate; 50 experts) and were rather aware of environmental issues (M= 4.14 out of 5, SD=0,61). After the selection phase, participants receive instructions on how to self-build the chosen LT system and were given 2 months to achieve the task. A group messaging channel allows the researchers to share information and instructions with the participants and to develop a community feeling. It is run by community managers to foster engagement and encourage participants to share tips and tricks. Participants will also be encouraged to take initiatives to smooth the construction process and communicate with others in the same area: buying resources together to reduce costs or proposing convivial gathering times and construction sessions in their local LT communities. Then, participants are invited to use the self-constructed system for 2 months. This duration relates to two life cycles for the crickets and four for the BSF larvae. The duration of the other missions was adjusted accordingly. We posit for instance that the Fog-Shower and Vegetarian Diet missions are more intrusive. To ensure maximum engagement, a single week of use is suggested to the participants. The frequency of data collection will however be increased to have a finer-grain view, and participants will be encouraged to use the system for a prolonged period.

The participatory study runs in paralel of a program led by Corentin de Chatelperron and Caroline Pultz to experiment with a low-tech futuristic habitat in Boulogne-Billancourt. Their objective is to explore, over four months, a frugal lifestyle in an apartment fully equipped with low-tech solutions and integrated into a network of local initiatives to meet their needs. They aim to demonstrate the feasibility and desirability of this lifestyle and to disseminate the low-tech narrative on a broader scale through a documentary film produced in collaboration with a television channel. The participatory program seeks to explore whether the low-tech systems tested in Boulogne-Billancourt are replicable across various contexts and acceptable to a diverse range of user profiles. It aims to assess whether these low-tech systems can be seamlessly integrated into everyday life and appeal to a broader audience beyond environmental enthusiasts.

4 METHODOLOGICAL REFLECTIONS

The investigation of the impact of LT on user experiences and, ultimately, on the potential adoption of LT system by a large audience, entails some complexity. We reflect on our methodological choices and trade-offs, as these insights can inspire future research. Noteworthily, the Biosphere experiment, thanks to its temporal scale, the diversity of missions proposed, and the number of participants involved, offers an ideal test-bed for the study of LT experience and acceptability. If studies of shorter timespans (e.g., lab user tests) can bring meaningful insights into specific UX dimensions, we advocate that only longitudinal in-situ studies can shed light on the complex relation between UX, needs, and adoption of LT systems.

These relations are reflected in our research hypotheses. As LT systems aim to involve users more, their efficiency in terms of effort or time spent in use, is not expected to be high. We however hypothesize that this reduced efficiency has a limited negative impact on adoption, as it is compensated by gains on other UX dimensions, such as feelings of competence and autonomy, or environmental utility (i.e. the system's ability to reduce environmental impacts). Additionally, self-constructing the LT systems is expected to foster positive emotions and have positive impacts on the feeling of competence and autonomy. The success of the building phase is thus deemed crucial to a positive UX and the adoption of a LT system.

4.1 User Diary

The temporal evolution of UX will be evaluated through a weekly user diary. Due to the large number of participants studied, mostly quantitative measurements were included. Quantitative analyses allow us to explore the experience costs and benefits associated with each system, to compare the differences in UX, and how these differences impact the adoption.

4.1.1 User Experience. To the best of our knowledge, no validated UX scale is currently designed to assess LT systems. We thus rely on a generic UX scale, complemented with additional measures when relevant. To ensure maximum engagement, the time needed to fill the diary has to be as short as possible. Hence, we selected the abridged version of the User Experience Questionnaire (UEQ) [34] to measure and compare various facets of UX. As LT raises specific questions around the pragmatic dimension of UX, utility and efficiency will be investigated through additional task-related questions, such as the time spent using or maintaining the product, and the perception of this duration. The effort required to use the LT systems will be measured through the single-item Borg Scale [6].

4.1.2 Emotions. Emotions are a fundamental component of UX [31] and seem particularly important in the LT context. In the project, a few missions for instance include insects, which can be linked to negative emotions (e.g., aversion, fear) and attitudes [20]. On the positive side, LT systems also enable the concrete implementation of ecological behaviors, likely fostering the emergence of a sense of pride [5]. We will use the Geneva Emotion Wheel (GEW) [32], a widely used and validated instrument to measure 20 emotions according to five levels of intensity. As for the UEQ scale, we expect this generic instrument to have several shortcomings in the LT context. First, the GEW might not be sensitive enough to capture nuances that are specific to the LT context, such as feelings related to sustainability, simplicity, or frugality. Second, it focuses on individual emotions, potentially overlooking the collective or social emotions [27] that might arise in participatory or community-based LT settings.

4.1.3 Psychological Needs. We also will investigate the 3 major psychological needs (Competence, Autonomy, and Relation) [35] through an adapted version of the scale by Hassenzahl et al. [16]. These psychological needs are linked to the valence of experiences, and low-tech systems are supposed, through the auto-construction, maintenance of the systems, and development of user autonomy, to foster the fulfillment of these needs and thus a positive UX.

4.1.4 Adoption. We will investigate the adoption of different low-tech products by measuring the intent to continue using the product after the experiment and to recommend the product to relatives. This variable is key in our protocols to gain insight into how the dimensions of UX drive a prolonged adoption of low-tech products.

4.2 Qualitative measures

Besides this large-scale measurement, a mixed-methods plan will be deployed to understand the specificity of LT-related UX. Qualitative methods will provide a more detailed understanding of the participants' rationale for rejecting or adopting LT systems.

4.2.1 User Interviews using UX Curves. User interviews will be conducted with a subsample of participants to explore specific UX aspects. These interviews will use the UX curve [23] method, which supports users in retrospectively reporting how and why their experience with a product has changed over time. It can inform participants' motivations to use the system, their most positive and negative experiences, and the problems encountered during the experiment. The configuration of the UX Curve interview allows the researcher to focus on specific facet of UX. A debriefing time will also focus on suggestions for improvement.

4.2.2 Online Asynchronous Focus Group. The WhatsApp channels will be used to set up weekly asynchronous focus groups around key questions. Through prompts proposed by the facilitators, participants will be invited to discuss facets of their experience. Text responses will be collected and analyzed. This method additionally allows to react to unexpected events, promoting flexibility of the protocol and mutual empowerment of stakeholders.

4.3 Methodological Challenges

Given the nature of the experiment and the large number of participants, methodological challenges arise. One of these challenges is linked to the self-construction phase, as participants might not all use identical products during the experiment. Their systems may vary slightly, with some participants potentially 'hacking' and improving their systems, while others may have malfunctioning systems. To account for this variability, participants will be asked to provide a picture of their systems just before the experiment begins. This will be reviewed to explain any unexpected responses to the questionnaire. Another challenge concerns the duration of the study, as it is difficult to ensure that every participant starts using their system at the same time. To address this, efforts are being made to inform participants about the participatory science protocol, and this will be taken into account during the analysis of UX evolution, as it is expected that this bias will diminish over time.

5 CONCLUSIVE REMARKS

Low-tech raises fundamental questions that we invite the HCI community to address. Our large-scale field experiment aims to explore these questions by investigating the specificity of LT systems' experience and its evolution across time. The goal is to identify leverage points and design opportunities to disseminate LT solutions more widely and improve their acceptance and adoption.

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