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The User Experience of Low-techs: From User Problems to Design Principles

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Abstract

Our technical culture is characterized by the development of increasingly complex artifacts. In this article, we introduce low-techs (sometimes termed "appropriate technologies"), which are alternative technologies designed to use fewer resources, target priority needs, and aim for a positive social and environmental impact. We describe their relevance for user experience researchers and practitioners interested in tackling environmental crises, and we discuss what actions can be conducted to improve low-techs' design and dissemination. Finally, from a survey of 396 participants, we derived 14 general user experience problems for low-techs to propose seven corresponding design principles: identify priority needs to derive necessary functionality, strike the right balance between empowerment and assistance, pay attention to non-functional features, facilitate discoverability, make artifacts and operation transparent, develop users' technical knowledge and skills, and compensate increased material loads and deficits. Practitioners can use these design principles to guide their development of low-techs.

Keywords

Technical culture, design principles, sustainability, low-techs, appropriate technologies, frugal design

Introduction

What Are Low-techs?

Mankind's technical behavior is characterized by the creation of increasingly complex artifacts over time (Cotterell & Kamminga, 1990, p. 9; Tainter, 1988, p. 3; Tomasello et al., 2009, p. XI). The negative consequences (economic, ecological, social, etc.) of this technical behavior have been unveiled and discussed since, at least, the 20th century (for example, Morozov, 2013; Mumford, 1967; Weil, 1958). Low-techs are alternative, less complex, and less resource-intensive technologies that aim for positive social and environmental impacts. The concept, or very similar concepts, has been discussed under many names such as "democratic technics" (Mumford, 1967), "liberatory technologies" (Bookchin, 1971), "intermediate technologies" or "appropriate technologies" (Schumacher, 1973), "convivial tools" (Illich, 1973), "soft technologies" (Samuel & Simonnet, 1976), and more recently, "low-techs" (Bihouix, 2014, 2020). They are also related to vernacular/indigenous technologies as identified by Thatcher et al. (2013) and Watson (2020). Low-techs can be defined as "artifacts whose design is constrained by the necessity to care for humans and the environments of production/use of which they are part" (Martin et al., 2022).

The development of low-techs has often been spearheaded by non-profit organizations such as the National Center for Appropriate Technology (USA, founded in 1976), the Low-tech Lab (France, founded in 2013), and the Low-tech Lab Yaoundé (Cameroon, founded in 2021). Another example, the Paleo-Energy association (France, founded in 2015), shows how the movement strives to build on and valorize past know-how by collecting forgotten and public domain patents (Carles et al., 2020).

A recent survey of 26 low-tech specialists found eight descriptors (empowering, renewing design practice, critical, de-mechanized, local, psychologically transformative, radically useful, and technically sustainable) that contribute to better frame low-techs (Martin et al., 2022). These descriptors reveal that, in addition to requiring a technical transformation, low-techs also require a human and social one for which user experience design offers relevant leverage (for example, when assessing needs and ensuring accessibility).

To give a concrete example of low-techs, we can compare a double-edge safety razor and a heated electric razor; the double-edge safety razor being a low-tech alternative to the heated electric razor. The double-edge safety razor is affordable, easy to maintain and recycle, and made with homogeneous materials that are recycling-friendly; the heated electric razor allows shaving and heating the face, is high priced and impossible to repair by the general public, and it is made with heterogenous materials that make them difficult to separate for recycling. It is of note that 1) the low-tech approach has also been applied to digital artifacts such as websites (Decker, 2017; Nova & Roussilhe, 2020) because low-techs are not necessarily mechanical artifacts, and that 2) low-techs are relative. For instance, an electric bike appears to be "low-tech" compared to an electric car, whereas the same bike appears less "low-tech" than a regular bike.

Low-techs are emerging as a credible option for the mitigation of environmental and social crises. For example, in France, actions have been undertaken to develop low-techs at a strategic/institutional level (Bihouix & Laboulais, 2022; Bonjean et al., 2022; Lopez et al., 2021) as well as at a manufacturing/work level (a French hiking brand is manufacturing a low-tech hiking stove, some bakers are using low-tech solar ovens, and farmers are manufacturing their own farming tools in order to remain in control of their means of production). Depending on the viewpoint, low-techs are either alternative or complementary to high-tech approaches (such as automation or electrification).

We argue that user experience researchers and practitioners could take more of an interest in those technologies by studying the specifics of users' interactions with them in order to contribute to low-techs' usefulness, usability, accessibility, and attractiveness through better designs.

The Relevance of User Experience for Designing Low-techs

The design community at large could commit, with its theories and methods, to making low-techs easier to use for everyone and therefore more widely available. Low-techs indeed suffer from characteristics that are "undeniably cruder and more basic, maybe a little less powerful" (Bihouix, 2020, p. xiv). Even more explicitly, a co-founder of the Low-tech Lab emphasized that "one of the main obstacles to the development of low-techs in France is the 'desirability' aspect. […] There is a lot of work to be done in terms of design to make these systems […] more aesthetic and (above all) ergonomic" (Nahmias, 2019).

We propose five perspectives concerned with theory, technical intensity, accessibility/usability, methods, and training (Table 1). Our study contributes to the methodological perspective by combining a bottom-up approach (collecting actual and perceived problems) with a top-down approach (using existing theories) to derive design principles in line with Jaferian et al. (2014) (as cited in Quiñones & Rusu, 2017).

Table 1. Possible Directions for User Experience Development of Low-techs

Orientation	**Description**
Connect with and develop relevant theories	Broaden the core theoretical foundations of user experience with relevant work such as works on "technition" (Osiurak et al., 2020), tool use (Baber, 2003), anthropometry, biomechanics, and more. Ethical developments are also of importance (for example, where does good user experience end and the "gilded cage," a very hedonic/attractive but ultimately alienating experience, begin?).
Contribute to the discussion regarding the relevant level of technical intensity	User experience specialists are usually involved with shaping how an artifact accounts for users' needs and capabilities, etc. The low-tech approach to artifact design also requires that designers pay attention to the relevant level of technical intensity needed for a given use-case.
Improve accessibility and usability	As for any new technology, accessibility and usability are key for its dissemination.
Develop new methods	Results from studies and relevant theories could help develop appropriate methods and tools. Introducing low-techs to our field could also help us be critical of current methods (do they contribute to feature creep or to an overemphasis on comfort and automation?).
Diversify practitioners' training	Adding low-techs to the training curriculum of students could diversify their representations of technology (currently dominated by high-tech examples such as apps and self-driving vehicles, etc.).

Method

Study Design

For our study, we implemented a mixed design. Indeed, the 10 low-tech artifacts were evaluated by different participants (between-subjects), but each participant had to successively evaluate two low-tech artifacts chosen randomly (within-subjects). The independent variables were the low-tech artifacts (the solar water heater, the rocket mass heater, the solar lamp, the pantry, the dry toilets, the hydroponics, the hydraulic ram, the black soldier fly larvae compost, the solar heater, and oyster mushroom cultivation). The dependent variable was the participants' verbalization of perceived or actual problems related to each low-tech artifact.

Participants

In total, 396 participants took part in the study, among which were 152 women and 244 men, aged 34 on average (standard deviation = 10). They were characterized by an intermediate, self-reported level of knowledge of low-techs (mean = 2.61 on a scale of 1–5; standard deviation = 0.97) and a very positive attitude toward low-techs (mean = 4.73 on a scale of 1–5; standard deviation = 0.55). They were recruited through the Low-tech Lab's social media pages. The Low-tech Lab (www.lowtechlab.org/en) is a French association dedicated to promoting, researching, and developing the low-tech movement. They provide consulting, training, and open-source documentation to individuals and organizations. The design of the study is summarized in Figure 1. (Sections 1, 2, and 4 of the questionnaire are not the focus of this article, but a dedicated technical report is available (Martin & Colin, 2021)).

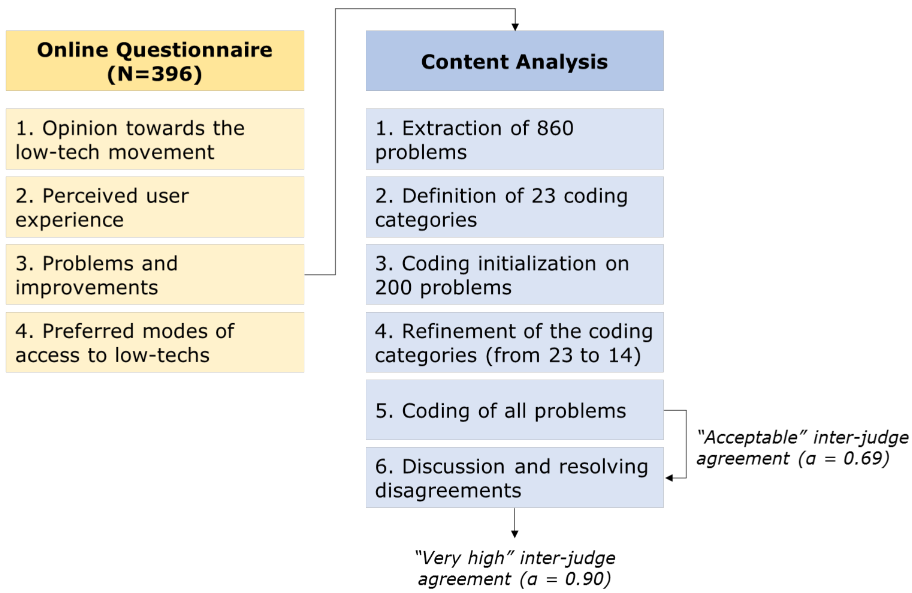

Figure 1. Summary of the design of the study.

Procedure and Materials

Content of the Questionnaire

To identify user issues related to low-techs, we administered an online questionnaire between July and August 2020. The 10 low-tech artifacts we surveyed were chosen by the Low-tech Lab among those that received the most visits on their website, including: the solar water heater, the rocket mass heater, the solar lamp, the pantry, the dry toilets, the hydroponics, the hydraulic ram, the black soldier fly larvae compost, the solar heater, and oyster mushroom cultivation (Figure 2).

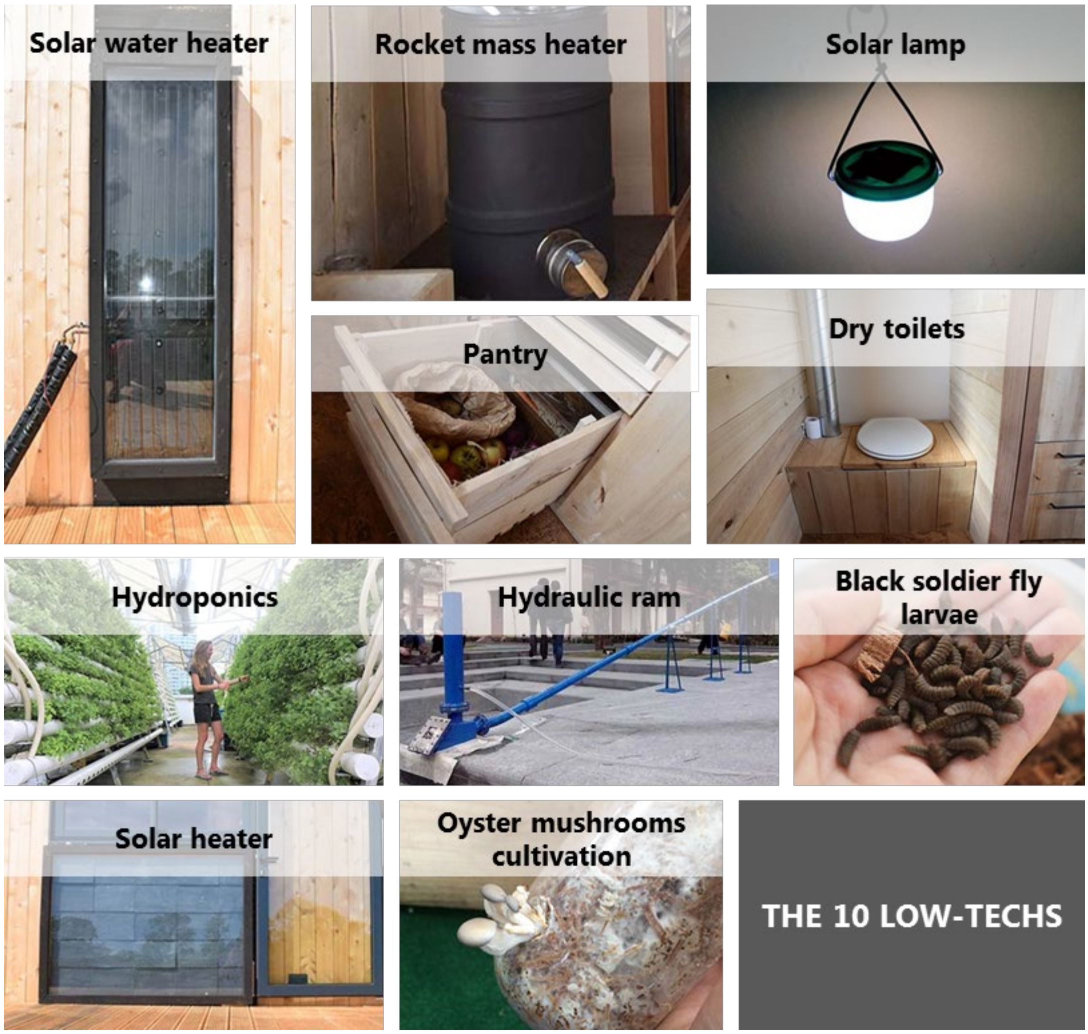

Figure 2. The 10 low-techs surveyed as artifacts (Credit: Low-tech Lab).

At the beginning of the survey, we gave information on the study to the participants (goals, contact email, and data anonymization) and collected their consent to participate after checking that they were of legal age. We asked each respondent to evaluate two low-techs for a total of 80 respondents per low-tech on average.

First, we asked participants to write down their opinion on the low-tech movement and to list the three words that they thought best represented the low-tech approach. For each of the two low-techs, and after seeing a picture and reading a short description, we asked participants to quantitatively evaluate their intention to use said low-techs and their perceived usefulness, ease of use, pleasure of use, and social desirability; the last four variables are known precursors to acceptability (Ajzen, 1991; Hassenzahl, 2003; Mahlke, 2008; Venkatesh & Bala, 2008).

We then asked participants to list problems and expected improvements for each of their two low-techs. As such we collected both perceived problems ("Maintaining a well-sterilized environment seems complex to me.") and actual user problems ("I have tried this before and the problem was that the oyster mushrooms grew all over the cardboard."). Thus, the data we collected provides information on user problems either through their direct experience (actual user problems) or through projected experience (perceived user problems), both being of interest. Having insights on usability perception is important because people use prospective judgement to make a decision before usage/purchase on the basis of the information in their possession per Hassenzahl (2003, 2008) and Kortum and Neal (2014) (as cited in Robertson & Kortum, 2020). In the following sections, we will use the term user problems as a generic term to cover both kind of verbatims.

Finally, we asked respondents to indicate their preferred modes of access (plans, collaborative workshops, or professional manufacturing and installation, etc.).

The participants' opinion toward the low-tech movement, the quantitative evaluation of the 10 low-tech artifacts, and the preferred mode of access are not detailed in this article as they are outside of its scope. Their analysis is available in dedicated reports (Colin & Martin, 2021; Martin & Colin, 2021).

The Corpus of Problems

The problems expressed by the participants formed a corpus of 860 unique problem verbatims ("[I need] directions to indicate [to me] which fruits/vegetables should be stored in the appropriate environment."). In total, 97 verbatims were excluded from the analysis because they were either not problems or their formulation was not understandable or required too much interpretation ("How is this low-tech hydraulic ram different from a conventional one?" or "Size of the pieces of wood.").

Coding Procedure

To organize the problems into meaningful categories, we undertook a qualitative analysis by classifying the problems according to a coding frame, and we evaluated the intercoder reliability.

First, one judge analyzed all the extracted problem verbatims to identify 23 possible categories of problems (plus one category for irrelevant verbatims as described in the previous section). Then, in order to confirm the relevance, wording, and definitions of the categories, we independently coded a set of 200 randomly extracted problem verbatims (covering five low-techs). Following this initial coding, and without comparing our actual coding, we discussed the relevancy and definition of the categories in order to inform the refinement of the coding frame to improve precision as proposed by Joffe and Yardley (2003) (as cited in O'Connor & Joffe, 2020). We reached an agreement. For example, the "Skills" and "Knowledge" categories were merged in a new "Know-how" category; "Maintenance" and "Repair" were merged into "Maintaining nominal mode," which also augmented an additional "Cleaning" dimension. A set of 14 user problem categories was identified (plus one category for irrelevant verbatims) with their corresponding definitions.

We then coded all problem verbatims independently according to these categories. In order to evaluate the reliability of the categories and definitions for classifying problems, we calculated the level of inter-judge agreement using Krippendorff's alpha (Hayes & Krippendorff, 2007) and found it to be "acceptable" ($\alpha = 0.69$).

To partly resolve the major coding disagreements, we discussed the seven categories of problems with percentages of agreement below the median of 55.25%. This was done by comparing the coding of the 110 corresponding problem verbatims one by one, of which 72 disagreements were resolved. The final inter-judge agreement after discussion (still using Krippendorff's alpha) was 0.90. During this final step, the coding categories were not renamed. In total, each judge coded 763 user problem verbatims, for an average of 76.30 problems reported per low-tech (standard deviation = 15.24).

Results

Our analyses led us to identify 14 main categories of user problems, agree on corresponding definitions, and identify recurring topics discussed by respondents for each category (Table 2). The average occurrence of the problems is detailed in Figure 3, although, it is worth noting that a study on digital interfaces showed evidence that frequent problems are not necessarily the most severe (Sauro, 2014).

Table 2. Finalized Categories of Low-tech Problems

	Users' problems category	**Definition of the category**	**Some recurrent components of the category**
1	**Living conditions compatibility**	The low-tech artifact is incompatible with the living environment of the user.	- Urbanism - Housing - Geography and climate
2	**Performance**	The low-tech artifact does not perform to the user's expectations.	- Durability - Reliability - Ease of use - Efficiency - Flexibility - Missing functionality or features
3	**Pleasure/ Ideology**	The low-tech artifact is incompatible with the user's values or aesthetic criteria.	- Aesthetics - Values - Lifestyle - Comfort
4	**Usefulness**	The low-tech artifact does not meet the user's goals, or the user's goals are already satisfactorily covered by existing artifacts.	- Redundancy with existing artifacts - Usefulness
5	**Production/ Installation**	The manufacture or installation of low-techs is a problem for the user.	- Implementation - Installation
6	**Components management**	The user has difficulties in accessing, storing, processing, or recovering tools, materials, raw materials, products, or waste associated with the low-tech artifact.	- Access - Storage - Tools - Raw material - Waste
7	**Know-how**	The user lacks knowledge or skills for the construction, installation, or use of the low-tech artifact.	- Knowledge - Skill
8	**Safety**	The low-tech artifact poses safety problems for the users, those around them, or the environment.	- Health - Hygiene - Safety - Environmental impact

	Users' problems category	Definition of the category	Some recurrent components of the category
9	**Additional load**	The low-tech artifact creates an additional burden for the user.	- Time - Cost - Cognitive load - Physical load
10	**Nuisance**	The low-tech artifact is a source of noise or visual or olfactory discomfort.	- Cleanliness - Disgust
11	**Maintaining nominal mode**	The user has difficulties in maintaining a satisfactory level of hygiene/cleanliness or technical operation.	- Cleaning - Maintenance - Repair
12	**Control**	The user does not have sufficient control over the operation of the low-tech artifact.	- Regulation - Control
13	**Legal compliance**	The low-tech artifact poses problems with regard to legislation or standards.	- Legislation - Standards
14	**Social dimension**	The low-tech artifact causes a negative social judgment to be made about the users or those around them.	- Social judgments - Social relations

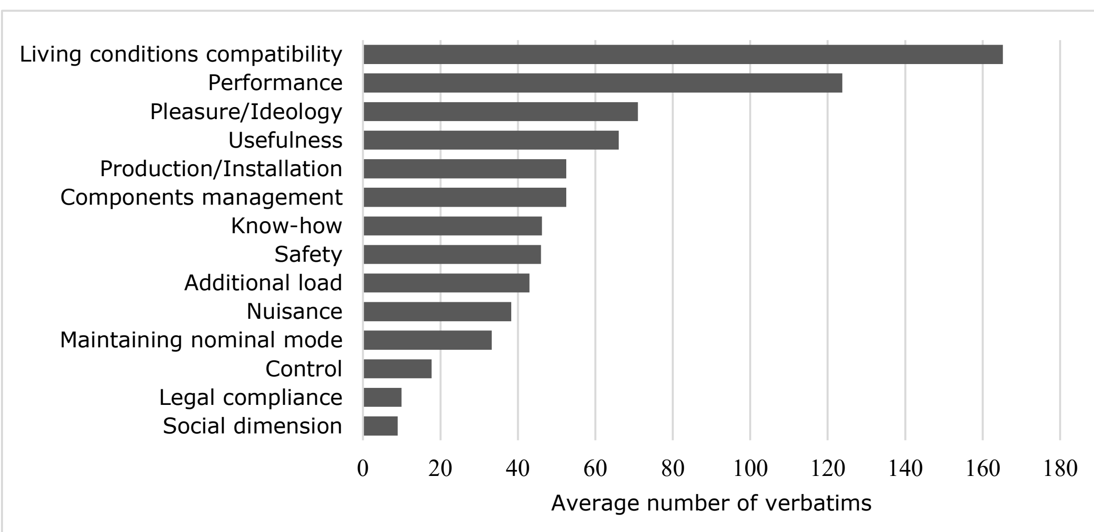

Figure 3. Number of occurrences for each category of user problems.

Recommendations

To supplement classic recommendations regarding usability such as that of Bastien and Scapin (1993) and Norman (2013, p. 72) or sustainable design such as that of Thatcher et al. (2013), we propose seven design principles derived from the results of this study as well as inspired by the literature on low-techs, technical cognition, and user experience. The goal of these principles is to help practitioners overcome user problems specific to low-techs as well as to be in line with the low-tech approach as described in the introduction of this study. The principles are summarized in Table 3. For each principle, we provide the problems they could help alleviate (referenced, between brackets, by their numbers as seen in Table 2), their definitions, and additional references that support them. The rationale behind their creation and means for implementing them are discussed after the table.

We highlight the following:

- These design principles aim to guide designers toward good practices while designing low-techs. They are middle-level principles rather than specific and practical guidelines per Schneiderman (2000) (as cited in Jaferian et al., 2011).
- More precisely, the principles aim to support the design of artifacts that are usable and in line with the human-side requirements of the low-tech philosophy (psychologically transformative, empowering/emancipating, radically useful, and de-mechanized).
- This is a first attempt at providing design guidelines for low-techs grounded in the literature and in our experiment. They will require further validation and discussion within the user experience community (see the Discussion section).
- The principles "identify priority needs to derive necessary functionality" and "strike the right balance between empowerment and assistance" can be used at a more strategic level. They allow for the arbitration of the level of technical intensity to be proposed, based on the needs and capacities of the users.

Table 3. Details of the Seven Design Principles

Principles	Definitions	Additional references to the current study
Identify priority needs to derive necessary functionality [1, 2, 3, 4, 8, 9, 12]	Organize the participative identification and prioritization of the situated needs that the low-tech artifact must meet in order to define the appropriate functionalities.	Bihouix, 2020, pp. 50–55; Keucheyan, 2019, pp. 175–196; Lizarralde and Tyl, 2018; Martin et al., 2022
Strike the right balance between empowerment and assistance [2, 5, 6, 7, 9, 11, 12]	Define the right level needed for the empowerment of the users and propose the appropriate level of technical assistance and service.	Bihouix et al., 2019, p. 16; Martin and Colin, 2021; Navarro et al., 2022
Pay attention to non-functional features [1, 3, 10, 13, 14]	Define which non-functional features are crucial for the use of the low-tech artifact and implement these features.	Baber, 2003, pp. 136–137; Baxter et al., 2017; Hassenzahl, 2003, 2004; Key and Lycett, 2017; Machin et al., 2007; Moshagen et al., 2009; Tractinsky et al., 2000; White and Foulds, 2018
Facilitate discoverability [2, 6, 7, 9, 11, 12]	Enable the autonomy of low-techs' users who do not have extensive knowledge of the artifact or activity at hand during any first steps they can take through improved discoverability of interaction possibilities.	Baber, 2003, p. 151; Baber et al., 2014; Norman, 2013, pp. 123–161; Osiurak et al., 2020
Make artifact and operation transparent [7, 8, 9, 12]	Enable users to efficiently monitor the operation of the low-tech artifact.	Baber et al., 2014; Morozov, 2013, pp. 326–328; Norman, 2013, p. 72; Rabardel, 2002, pp. 144–148

Develop user technical knowledge and skill [2, 6, 7, 9, 11, 12]	Enable the use of low-techs by different users' skill profiles and support the development of user skills related to the production, installation, and use of the low-tech artifact.	Baber et al., 2014; Osiurak et al., 2020
Compensate increased material loads and deficits [1, 5, 9]	Pay attention to the material flows that the low-tech artifact requires or generates to be usable.	Martin and Colin, 2021

Numbers between brackets in the Principles column refer to the category of problems (Table 2) which are addressed by each principle.

Identify Priority Needs to Derive Necessary Functionality

To be radically useful, the situated priority needs (biological, psychological, and interactional) that the low-tech artifact must meet have to be identified. To be of low technical intensity, only the necessary and appropriate functionality should be implemented. If this is not done properly, necessary functionality may not be supported by the low-tech artifact, which results in a lack of usefulness or in a negative impact on the use of the low-tech.

As means to implement this principle, we propose

- including a representative sample of users in a participatory needs-deliberation process,
- identifying priority needs among candidate needs in regards to the necessities of human physiology, well-being, interaction, social, and environmental context,
- deriving necessary functionalities associated with identified priority needs, and
- clearly communicating the process and reasoning behind the identification and selection of priority needs and necessary functionalities to users in order to make limited functionalities more acceptable.

Strike the Right Balance Between Empowerment and Assistance

To empower users, some operations that can be taken over by them should be de-mechanized or de-automated. This empowerment leads the user to take over tasks such as production, installation, maintenance, operation, or component management, which are currently handled by technology or organizational providers. This can result in negative consequences for users, including overload, lack of control, or difficulty of use.

As means to implement this principle, we propose

- adapting the level of automation to the different users' profiles,
- offering services to compensate operations that users are not able or do not wish to do, and
- providing adapted modes of access such as full autonomy, ready-made purchase, or direct learning.

Pay Attention to Non-Functional Features

Because low-tech artifacts are often made of recycled materials and are self-built and/or rudimentary, the non-functional aspects are often set aside. However, like all artifacts, low-techs involve non-functional aspects related to situated norms (ideological, social, aesthetical, and cultural) that must be implemented. These non-functional features have an impact on the desirability and usability of the artifact and on the understandability of its purpose.

As means to implement this principle, we propose

- decreasing the sources of disgust (withdraw, conceal, or reframe meaning, etc.),
- looking for alternative needs' satisfiers (for instance, avoid plastic containers for food),
- avoiding a makeshift appearance by paying attention to aesthetics, and
- taking into account the socio-cultural context of the users.

Facilitate Discoverability

Using low-techs often requires users to have extensive knowledge. This is sometimes due to their makeshift appearance (which makes the signifiers imperceptible or non-comprehensible to users) or due to the necessity to perform new tasks (usually handled by the technology or organizational provider). These can cause users difficulties when attempting to identify possible actions, and ways to perform them, during any first step they might take.

As means to implement this principle, we propose

- giving information on user-operated actions, which are usually technology-operated, and making visible and accessible interactive parts of the artifact,
- making interactors intelligible independently of users' knowledge and skills,
- relying on basic handling/grasping, and
- displaying information that allows the imitation of movement.

Make Artifact and Operation Transparent

In an attempt to pursue a lower technical intensity, low-techs may not offer sufficient information on the status of the artifact or the activity at hand, preventing the user from reacting appropriately or effectively or preventing them from understanding the operation of the artifact. Furthermore, the lack of information on material or energy flows does not make it possible for the user to be aware of the physical reality of its use and therefore form sustainable behaviors.

As means to implement this principle, we propose

- providing immediate direct/indirect informational feedback (olfactory, haptic, auditory, or visual) needed for operation and related to the low-tech artifact or to the activity at hand, and
- defining the right amount of friction (discomfort) that the artifact must provide in order for the users to be conscious of material realities (such as water or energy consumption) without users being overwhelmed.

Develop User Technical Knowledge and Skill

Tasks usually handled by technology or by the organizational provider regarding the production, installation, maintenance, and use of a low-tech artifact may not be supported. Missing technical knowledge or skills can lead to accessibility, usability, safety, or performance issues.

As means to implement this principle, we propose

- promoting technical reasoning through feedback on the artifact and activity status,
- opening up the possibility of learning through imitation (such as face-to-face training),
- providing documentation that explains theoretically how a low-tech works, and
- providing documentation that describes step-by-step complex and non-routine operations.

Compensate Increased Material Loads and Deficits

Material processes that were handled by organizations and utilities are transferred to the users, which may result in an additional burden or be incompatible with users' current living conditions.

As means to implement this principle, we propose

- identifying and compensating for tensions regarding access to raw materials and waste disposal that were handled previously by infrastructure or organizations,
- identifying and compensating for the lack of tools that are needed to manufacture or maintain low-techs, and
- offering support through services (for example, delivery and pick-up of materials).

Discussion

Limitations

Regarding the sample, as the participants were recruited through the social media of the Low-tech Lab, some level of self-selection bias might be in effect. Similarly, the very high self-reported attitude toward low-techs (4.73/5 on average) raises the question of missing problems that such a positive-minded sample might not recognize as worth mentioning. Nevertheless, the breadth of the rated low-techs, the large sample we used, and the high number of problems collected as well as the coding of these problems into broad categories make it less likely that important problem categories were missed.

The problems originate from declaration of both actual and perceived problems, and as such they might be skewed in favor of perception instead of reality. Some additional work on the ecological use of the design principles is thus needed (see the Future Directions section). In addition, previous studies have shown that prospective assessments are often more positive than lab assessments and indicate that for physical artifacts (such as timers and can openers) more accurate prospective ratings might depend on the prior experience of the raters with similar artifacts (Robertson & Kortum, 2020). We did not assess this. While beginning the construction of the design principles, we diversified the insights we used as a basis to devise the principles in order to mitigate these issues (Table 3, column 3 shows corresponding references).

Furthermore, it is important to note that the surveyed low-tech artifacts were selected on the basis of the amount of internet traffic they received, which may imply that they are artifacts with a high perceived value and interest. However, a high value or interest does not necessarily make them representative of low-techs in general, even if that argument could be made on the basis of their diversity and number. Finally, our guidelines were derived from inspection of physical low-techs. Even if the guidelines could be applicable for digital low-techs (such as low-tech websites), they might require some adaptation or at least further discussion in this case.

The Specifics of Interacting with Low-techs

Low-techs are user-intensive. An important part of their problems (such as components management, know-how, additional load, and control) is the consequence of the strong involvement required from users. Indeed, because the low-tech approach is meant to empower users—and because low-tech artifacts are as much as possible de-mechanized, non-digital, and low in energy consumption—the user takes back in charge a large part of what is currently accomplished by automation (for example, cleaning in the case of the dry toilets) or standardized industrial processes (such as manufacturing). This may cause additional loads (cognitive or temporal, etc.) which warrant the attention of practitioners.

Low-techs are often makeshift or rudimentary artifacts. Some problems are related to the makeshift or rudimentary nature of low-techs (such as legal compliance, safety, performance, and pleasure/ideology). In line with the perspective of empowerment, but also of environmental sustainability, low-techs are not necessarily manufactured and installed by professionals; they are built in part from upcycled materials and tend toward technical minimalism. This has consequences for the safety of their production (such as handling of waste products) and use (for example, risk of leakage) but also for their performance, usability, and ability to comply with regulations and appearance. This requires special attention for the designer because several of the latter can cause a degradation in the user experience or a risk of injury.

Relevance of the "Living Conditions Compatibility" Category

As highlighted in the Results section, a frequent problem might not necessarily be an important one; more precisely we tend to think that this problem is more of an artifact of our study design. Indeed, low-techs are striving to be highly situated and localized artifacts that cater to specific needs. However, during our study the participants were tasked with evaluating low-techs independently of their relevancy to their context of use. It seems rather normal that a hydraulic ram be incompatible with the lifestyle of an urban dweller. This is not a problem with the hydraulic ram *per se*, this is a limitation of our study when matching respondents with the two low-techs they had to assess (which was randomized).

Low-techs Both Empower and Question Human-Centric Practice

Contemporary Western user-centered fields, such as ergonomics, were developed in the context of industrialization (Guérin et al., 2021, p. 49; Laville, 2004, pp. 41-44; Moray, 2008). As such, they tend to accompany the generation of new or artificial needs in order to generate economic growth, sometimes with little attention for human flourishment, which Light et al. (2017) call "bovine design." In contrast, low-techs offer a renewed perspective for human-centric practices: By proposing to recompose our relationship with technology, low-techs allow researchers and practitioners to imagine a future in which they are not merely secondary actors of our technical culture as when they provide adaptations or implement specifications in support of business or engineering teams. This is indeed a way for researchers and practitioners to contribute to the definition of the proper level of technical intensity an artifact should be given for a corresponding use-case when sustainability is kept in mind.

In the end, low-techs raise questions about the future of our field. Should we start questioning the dominant user experience practice of maximizing comfort, automation, and performance in fear of creating a techno-cocoon (Damasio, 2010) around users? Should we keep some degree of friction in products and services in order to "highlight complex issues that are very hard to see in a frictionless world" (Morozov, 2013, p. 327) and, thus, contribute to making humans more in charge of their own lives and aware of their needs, choices, and consequences?

Future Directions

These principles are a necessary first step upon which further research can build. At least two future actions are possible to assess the validity of our principles in terms of their usability by design practitioners and their reliability for the detection and mitigation of problems. First, the principles could be tested in a laboratory setting by practitioners to see if they use them in a homogenous manner and if they find them understandable enough (for example, using a protocol similar to Nemery and Brangier (2014)). Second, the representativity of the principles could be verified 1) through user testing in order to discuss the relevancy of the principles compared to problems collected in an ecological or laboratory setting and 2) through discussion with manufacturers of low-tech artifacts who have access to some actual user problems. Nevertheless, at this stage, we are confident that the seven principles can help mitigate important design issues and keep designers in line with the low-tech approach. The design principles could also support generalist design practitioners interested in contrasting their day-to-day practice with the low-tech approach (for example, during a reflective practice workshop, a kind of practice-based professional learning event (Finlay, 2008), although it is rare in our fields).

Another extension of this research could address more general socio-psychological factors that could explain the propension of some people to be interested in low-techs (beyond concern for climate change). For example, in a recent study Navarro et al. (2022) showed that three factors can explain the propension to use smart tools: an effectiveness/efficiency dimension, a hedonic/social dimension, and a proneness to delegate. How would low-techs' users fare on the corresponding scale (STP-Q)? Are they less prone to delegate and less sensible to the hedonic aspect of tool use? Answering these questions would help to better understand the hurdles, perception, and facilitating factors of low-techs' use.

Conclusion

The interest in sustainability and combatting climate change has been developing within user-centric fields, and possible areas for contribution have been highlighted (Frick, 2016; Kramer, 2012; Light et al., 2017; Radjiyev et al., 2015; Thatcher & Yeow, 2016). However, one topic has been mostly left untouched: the role of these fields in shaping a technical culture that is centered on mostly high technologies, which are not necessarily compatible with human well-being and planetary boundaries. In this article we propose that alternatives, such as low-tech artifacts, also deserve interest from user experience researchers and practitioners for their contributions to climate change mitigation. More precisely, we propose that researchers and practitioners could focus on the following to help develop low-tech artifacts: connecting with and developing relevant theories, contributing to the discussion regarding the relevant level of technical intensity, improving accessibility and usability, developing new methods, and diversifying practitioners' training.

In order to make a first step in this direction, we surveyed 396 participants on 10 low-techs, thus collecting 763 user problems. Grouping them together led to the creation of 14 broad categories of problems (living conditions compatibility, performance, pleasure/ideology, usefulness, production/installation, components management, know-how, safety, additional load, nuisance, maintaining nominal mode, control, legal compliance, and social dimension) with a high level of agreement between the two judges. From this, we devised seven design principles aimed at supporting the design of low-techs:

- identify priority needs to derive necessary functionality,
- strike the right balance between empowerment and assistance,
- pay attention to non-functional features,
- facilitate discoverability,
- make artifacts and operation transparent,
- develop users' technical knowledge and skill, and,
- compensate increased material loads and deficits.

In the end, we argue that improving the user experience of low-techs is mutually beneficial. On one hand, it will help improve the attractiveness of technologies that are frugal and therefore more compatible with planetary boundaries. On the other hand, it will broaden the scope of user-centric fields, help us question the complex technical landscape we contribute to shaping, and determine to what degree we should actually improve the user experience. Of course, low-techs are not a cure-all, and we should remain especially attentive to actual users' behaviors in order to detect any rebound effect.

Tips for Usability Practitioners

- The low-tech approach is an interesting alternative when looking for technical solutions that can have a reduced impact on the environment as well as a positive impact on human well-being.
- Low-techs tend to be user-intensive and suffer from a makeshift appearance, which generates user problems. The seven design principles can guide you toward possible solutions.
- You can use the seven design principles to guide you when designing low-techs but also as a way to reflect on your day-to-day practice within the mainstream user experience paradigm (for example, during reflective practice workshops).
- When working with prospective inspection, strive to collect the level of actual experience (if any) of your participants with the class (or a similar class) of artifacts targeted by your study in order to get some degree of reflection on your results.

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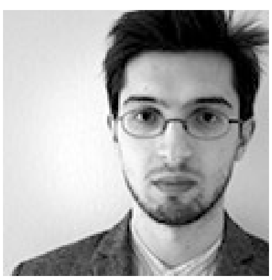

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