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Mapping the low-tech concept: guiding design towards sustainable technologies

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ABSTRACT

The current exposure of societies to climate risk is largely due to the evolution of our technical culture. Ergonomics has encountered difficulties to mitigate the impact of this technical culture (automation, specialization, etc.) on human well-being. Low-techs propose a reconfiguration of our relationship to technology but suffers from being ill-conceptualized. In order to map this field, and to initiate a debate within our community, a study was conducted with 26 experts. The results revealed that 8 categories of criteria can contribute to frame low-techs: Empowering/Emancipating, Renewing Design Practice, Critical, Demechanized, Situated, Psychologically Transformative, Radically Useful, and Technically Sustainable.
This study shows that the low-tech approach is more than an opposition of technical degree with *high-techs*, that ergonomics is legitimate to act within this framework and that low-techs offer a technical perspective that empowers ergonomists.

Keywords: History and future of ergonomics, Political comment and ethical considerations, Use of expert opinion, User's model, mental models and cognitive map.

INTRODUCTION

The "low-tech" concept has been popularized in France in the 2010s by Philippe Bihouix (Bihouix, 2014, 2020) and by the creation of the Low-tech Lab association. Often used in contrast with "high-tech", the term is in line with techno-critical works of the XXth century which showed the situations of vulnerability (economic, ecological, social) and illusions created by technological progress (e.g., Ellul, 1964; Illich, 1973b; Mumford, 1967; Weil, 1958). It gives them a concrete answer.

Like "high-tech", the concept has been described as destined to remain blurry and its boundaries destined to remain permeable (Bihouix, 2014/2021, p. 94). The most widespread definition in France might be the Low-tech Lab's, according to which low-techs are "*objects, systems, techniques, services, know-hows, practices, behaviours and even ways of thinking that use technique and technology according to three principles: Useful. Accessible. Sustainable.*" (Low-tech Lab, n.d.). "Useful" being understood here in the sense of meeting priority needs. To illustrate this definition we can compare a safety razor (usefulness: allows shaving, accessibility: affordable price, handling is simple for people who are not comfortable with digital technology; sustainability: easy to repair and recycle, has only three different components, is made of homogenous materials) and a connected razor (usefulness: allows shaving and receiving shaving advice; accessibility: razor and blades are both expensive ; sustainability: is impossible to repair by the general public, made of heterogeneous materials that are hard to separate and to recycle, suffers from numerous potential sources of failure). Low-techs are therefore of twofold interest for their respect i) of human beings (technology becomes affordable again, human beings remain masters of it since they can understand/repair it, etc.) and ii) of the environment in which humans live (frugality in terms of resources, reparability, recyclability, etc.). Less and less a utopia, low-techs are spreading in society as a credible solution to the societal and environmental crisis (e.g., a major French sporting brand is manufacturing a low-tech hiking stove, bakers and roasters are equipping themselves with solar ovens).

A certain agreement exists regarding the sterility of opposing low and high-techs, even if one is conceived in relation to the other (Grimaud et al., 2017a, p. 13). For example, it is possible to imagine a low-tech digital artefact (e.g., Decker, 2017; Nova & Roussilhe, 2020). The relative aspect of low-techs is nevertheless important, an electric bike will seem "low-tech" compared to an electric car, on the other hand this same bike will be less "low-tech" than a regular bike.

Research on low-techs are rare even if they have developed in recent years (e.g., Grimaud et al., 2017b; Martin & Colin, 2021; Meyer, 2021; Nova & Roussilhe, 2020). Funding is indeed still scarce for a topic that goes against the dominant industrial paradigms.

LOW-TECH AND ERGONOMICS

What is the interest for ergonomics to be concerned with low-techs? We can identify at least three reasons: regain some power to act, seize its disciplinary legitimacy and contribute to the fight against the environmental and societal crisis.

Contemporary Western ergonomics developed in the context of industrialization (Guérin et al., 2021, p. 49; Laville, 2004, pp. 41–44) and is financially supported by it. It is therefore constantly struggling with its paradigms (specialization, division of labour, quantitative approach to work, optimization, standardization, automation, prescription and subordination etc.). It has noted the resulting damages without always being able to respond to them other than by proposing adaptations (*"passive revolutions in the face of the waves of transformation that workers frequently endure*" Guérin et al., 2021, p. 380) and, in the worst case, by acknowledging its powerlessness ("*it can do little to remedy alienations [...], a science of human work, it loses its rights when the latter has disappeared*" Briand & Cazamian, 1996, p. 537). Low-techs therefore offer a new perspective to ergonomics. By integrating them to its practice (lab and field work), ergonomics would perhaps find a new power of action allowing to free itself, in part, from the "*strong dependence to the way ergonomics has been built: by the experience as it has been set up in an industrial economy and in big companies*" (Cerf, 2021).

On a more theoretical level, low-techs question key ergonomics concepts such as needs, actual behaviours or cognitive aspects of handling artefacts that are not, or slightly, digitalized (Colin & Martin, 2021). In the case of behaviours, they lead, for example, the ergonomist to think about the environmental impact of the actual behaviours generated by the artefacts (ibid.).

Finally, low-techs are very much situated at the crossroad of "classic" ergonomics areas: work (already mentioned previously), accessibility, and usability. Regarding the latter, one thinks in particular to their "*undeniably cruder and more basic, maybe a little less powerful*" characteristics (Bihouix, 2020, p. xiv) which raises questions of discoverability, signifiers, constraints etc. Practitioners of the low-tech movement themselves recognize the need for ergonomics developments. One of the Low-tech Lab's co-founders indeed stated: "*[…] there is a lot of work to do regarding [their] design to make these systems more aesthetic and (especially) more ergonomic […]*" (Nahmias, 2019).

Faced with the environmental and societal crisis, design ergonomics has entered a stage marked by ethics (Bastien & Brangier, 2021, p. 231) where low-techs seems a promising avenue. Indeed, by addressing our relationship with technology, low-techs are a way to sustainably transform our societies, and even to respond to new risks (such as shortages of raw materials).

PRESENTATION OF THE STUDY

The study took place in the context of a "PRC" (for "*Projet de Recherche Collaborative*", or Collaborative Research Project) entitled "Viabilité low-tech" (Low-tech viability) funded by the EcoSD association. The goal of the PRC was double: 1) to carry out a review, in France, regarding the low-tech concept and 2) to create tools to facilitate the development of low-tech initiatives, their funding and their recognition.

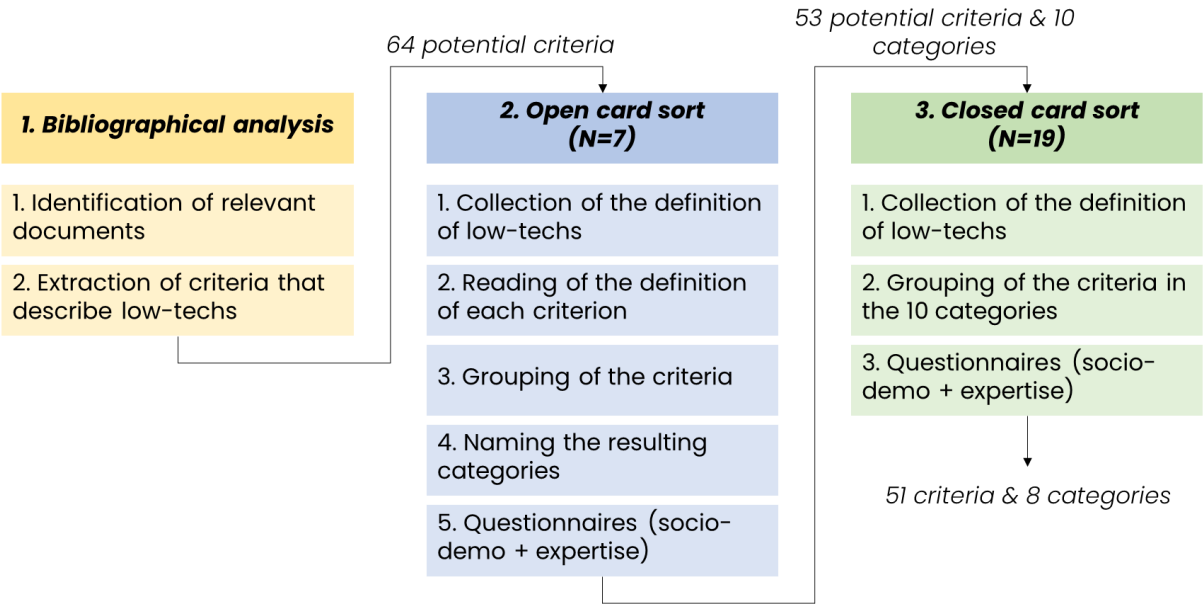
The study articulates two card sorting experiments, on the basis of a bibliographical analysis, in order to map the mental representations, regarding low-techs, of experts from the field. Card sorting is a widely used method in the humanities, especially for building web architecture (Lallemand & Gronier, 2015). It seeks to highlight the categorizations used by individuals as an

indicator of their mental representations (Fastrez et al., 2009). This method is based on the mental capacity of individuals to organise information into hierarchical structures according to their common properties (Collins & Quillian, 1969) and relies on "*the assumption that an important part of people's knowledge lies in the categories they use*" (Fastrez et al., 2009). This method was chosen because it is effective in organising a large number of elements. More specifically, it is relevant both for studying mental representations and for producing a "cartography" that is easy to reuse, modify, discuss etc.
In concrete terms, participants were asked to organise a series of criteria used to describe low-techs (extracted from the literature). Data analysis made it possible to extract an "average" cartography that could serve as a basis for the ergonomics community to appropriate and debate the low-tech concept.

METHOD

The method we used is summarized in **Figure 1**.

Figure 1. Summary of the method.



Step 1: Extraction of the criteria through bibliographical analysis

The goal of the bibliographical analysis was to identify, as objectively and comprehensively as possible, criteria that could describe the low-tech concept.

Document collection
The documents were identified via an Internet search engine. They were scientific articles, news articles and technical notes. The search took place in 2020, documents were included if they contained the keywords "low-tech" or "low technologies" in their text and if they were post-2000; thus 17 documents were identified and included in the study.

Extraction of the criteria
Textual fragments that characterized the low-tech concept were extracted by 3 coders (two engineering students and one eco-design engineer). After "initializing" coding (i.e., coding the same text separately and resolving coding conflicts together), the coders divided the texts among themselves. Fragments for which the individual coders had difficulties to make a decision were subjected to discussion until an agreement was reached.

Processing the criteria
Each fragment was then reframed as a criterion (e.g., "*low-techs are techniques that consume little energy*" became "*energy efficient*"). Similar and duplicate criteria were merged. Finally, the 64 criteria obtained in this way were validated by 3 researchers (two ergonomists and an engineer in eco-design). The aim was to check that the criteria were of the same level of granularity and that they were understandable. Definitions were written for each of them using their original context as basis.

Step 2: Organization and validation of the criteria through card sorting experiments

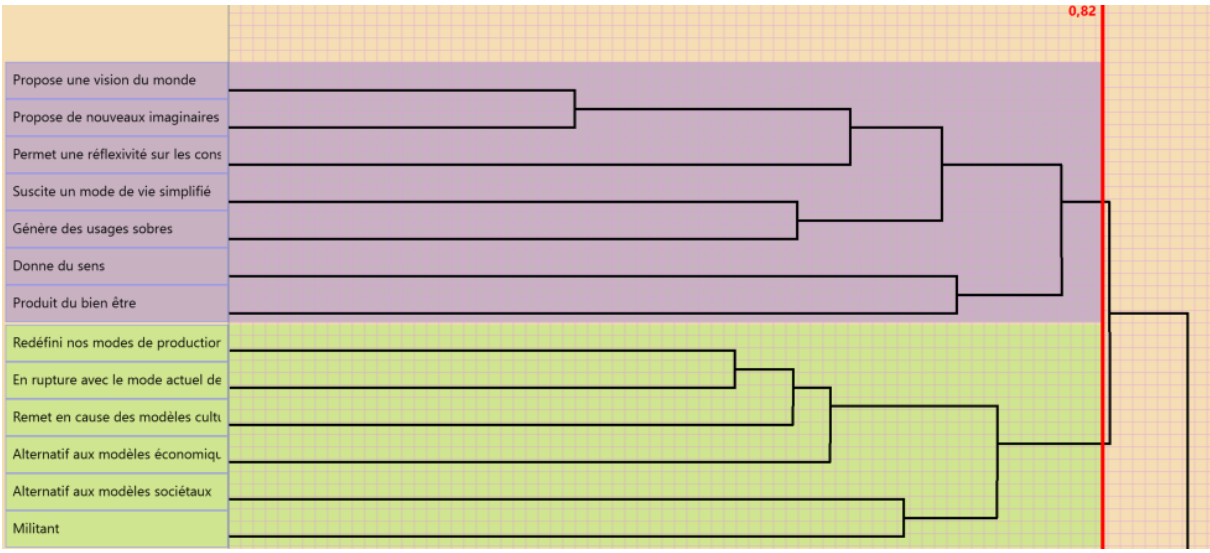
The goal of the card sorting experiments was to enrich and validate the relevance of the criteria identified during the bibliographical analysis while identifying the structure and organization of these criteria according to the mental representations of experts. The card sorting experiment was composed of a first "open" phase followed by a "closed" phase.

Phase 1: Open card sort
In this first phase, the aim was both to validate the criteria collected in the bibliographical analysis (by adding missing criteria or by removing irrelevant ones) and to identify the names of the categories according to which these criteria could be organised.
A total of 7 French-speaking participants took part in the open card sort, 2 women and 5 men aged between 29 and 49 (mean = 34.50; standard deviation = 7.48). The participants were identified within the "low-tech" community; they were people whose job title clearly mentioned low-techs (e.g., "Low-tech project manager"), leaders of associations dedicated to low-techs or people working to conceptualize low-techs (i.e., having published books or research articles on the subject). Participants' perceived expertise was

collected using a 5-point Likert scale (inspired by Johanna & Heijden, 2000). Their mean perceived expertise in the low-tech field was high (mean = 4.07; standard deviation = 0.76). They had been invested in the low-tech field for several years (mean = 4.33 years; standard deviation = 2.07 years).
Participants did not receive a financial compensation and gave their informed consent before participating in the study.
The card sorting experiments were conducted individually via a video conferencing software under the guidance of a researcher. After giving their definition of low-techs, participants were asked to read the 64 criteria and their definition. They then had to group these criteria according to their own logic and name the resulting groups. They were given the opportunity to add or remove any criteria (for example, if they seemed irrelevant or redundant).
New criteria proposed by participants were added to the list and criteria with more "requests for deletion" than the median (2) were removed for the next phase.

A total of 19 French-speaking participants took part in the closed card sort, 4 females and 15 males between the ages of 23 and 55 (mean = 28.00; standard deviation = 5.37). As in phase 1, participants were low-tech experts and were identified for their professional low-tech expertise. Their average perceived expertise in the low-tech field was high (mean = 4.03; standard deviation = 0.81). They had been invested in the low-tech field for several years (mean = 4.81; standard deviation = 6.21). Participants did not receive a financial compensation and gave their informed consent prior to participating in the study.
The card sorting experiment took place individually and autonomously through the KardSort website (kardsort.com).
After giving their definition of low-techs, participants were asked to group the 53 potential low-tech criteria (presented in random order) into the categories identified at the end of phase 1. Again, they were given the opportunity to delete any criteria.
Results were analysed with the CaSoLysis 2.0 software

Figure 2. Extract from the dendrogram for the categories "Psychologically transformative" (purple) and "Critical" (green). The red line indicates the selected classification level.



In total, 4 potential criteria were added by participants. In contrast, 11 potential criteria were removed.
Finally, the names of the categories of criteria given by the participants were reviewed and grouped thematically by 2 researchers (ergonomists) to form meaningful and exclusive categories. This analysis resulted in the emergence of 10 categories. It should be noted that 4 criteria were transformed into categories because their meaning completely covered the content of a category established by participants, thus avoiding any recursion.

Phase 2: Closed card sort
In this second phase, the goal was to quantitatively validate the organization of the criteria and the existence of the categories of criteria as identified at the end of the first phase.

(see **Figure 2**). By analysing the agglomerative hierarchical cluster produced by the software, we were able to identify groupings of criteria that would allow us to validate the structure of their categorization. We then used the category/criteria matrix to observe in which category each criterion was predominantly classified in order to verify the denomination of the categories.
Thus, i) 2 categories were added and ii) 5 categories from phase 1 were combined to form 2 new categories. In addition, 1 category and 2 criteria were deleted.

RESULTS

Our analyses allowed us to identify 51 low-tech criteria that have been structured in 8 categories by the participants (see **Table 1**).

Table 1. Classification of the 51 criteria in 8 categories that can be used to describe low-techs.

Categories	Definitions	Criteria
Technically sustainable	Low-techs have the least negative possible impact on the environment by providing a moderate technical response.	Ecological - Do not produce waste massively - Recyclable - Sustainable - Respect planetary boundaries - Reusable - Energy efficient - Resilient - Robust - Repairable - Contrary to the logic of exploitation - Sober design - Low complexity - Sober in materials - Modular - Respond to constrained design
Psychologically transformative	Low-techs generate psychological changes.	Propose a vision of the world - Propose new imaginaries - Generate a simplified way of life - Generate sober uses – Allow for a reflexivity on social consequences - Give meaning - Produce well-being
Critical	Low-techs question the dominant technical and social practices.	Alternative to economic models - Alternative to societal models - Break with the current mode of consumption - Redefine our modes of production - Challenge cultural models - Militant
Situated	Low-techs address the specific problems of a territory and uses local resources.	Interstitial - Locally repairable - Locally produced - Locally adaptable - Decentralized
Empowering/Emancipating	Low-techs give back some power to act, develop capabilities and enable growth.	Inclusive - Fit into the notion of "commons" - Collaborative - Open - Controllable - Reproducible - Simple to use - Accessible manufacturing - Allow for the democratic reappropriation of production tools
Radically useful	Low-techs' functions meet priority needs.	Question the degree of usefulness - Functional - Efficient - Versatile
Renewing design practice	Low-techs question design practices.	Resourceful - Implement new design methods
Demechanized	Low-techs favour manual energy while being as little automated as possible.	Labour intensive - Based on ancient techniques and know-how

LIMITS AND DISCUSSION

Limits

We can identify two limits to the study:

- the probably high cognitive load generated by the experiment: the participants had to organise between 50 and 60 criteria, which raises the question of the quality of their ranking and of the instrumentation of card sorts involving a high number of items.
- the exhaustiveness of the bibliographical sources: with 17 documents, we cannot claim to have exhausted all possible criteria, only to have found a compromise allowing for the feasibility of the study by covering the majority of them.

Discussion

Although it developed with a view to accompanying industrialisation, ergonomics has produced numerous works critical of its effects. By proposing to reconfigure our relationship with technology, low-techs enable ergonomics to imagine a future in which it is not merely a secondary actor of technical culture, present only to mitigate degraded work and use situations. Ergonomics could therefore commit itself, with its theories and methods, to making low-techs easier to use for everyone and therefore more widely available. For example, by developing new tools (needs analysis grid, ergonomic criteria for low-techs, etc.). In addition, low-techs, as described by the 8 categories of criteria presented in this article, also enriches the themes treated by ergonomics by bringing forward relatively absent concepts, such as emancipation (Béguin, 2021).

Low-techs also question the future of design ergonomics: joining the dominant practice in "user experience design", consisting in "opacifying" artefacts (i.e., by concealing the "wheels of the machine") and to aim for optimal comfort and performance, even if it means creating a "*techno-cocoon*" (Damasio, 2010) around users? Or, with low-techs, to participate in unveiling the infrastructure of the industrial economy, the "*material reality of our economic system*" (Bihouix, 2020, p. xvi), which "*can highlight complex issues that are very hard to see in a frictionless world*" (Morozov, 2013, p. 327). Thus, contributing to making people masters of their own lives, aware of their needs, their choices and their consequences. *In fine*, low-techs appear to be part of a larger concern for the compatibility of technology with "*the permanence of an authentically human life on Earth*" (Jonas, 1985).

The term "low-tech" also raises questions. Intuitively it points to the rustic, uncomplicated aspect of these artefacts, and much less to the human aspects described in this article. Should we change it? Perhaps the first thing to do is to update its definition. Using the results of the card sort, we propose to define low-techs as "*artefacts whose design is constrained by the necessity to care for humans and the environments of production/use of which they are part*". This definition and the 8 categories of criteria identified in the study (Empowering/Emancipating, Renewing Design Practice, Critical, Demechanized, Situated, Psychologically Transformative, Radically Useful, and Technically Sustainable), leads to the observation that the term "low-tech" is inadequate and to reflect on the use of more open and representative terms such as "*convivial tools*" (Illich, 1973b) or "*fair tools*" (Illich, 1973a, p. 27). However, this is difficult to envisage in France, where "low-tech" has been widely adopted, unlike in Anglo-Saxon countries where it is rarely used. A worldwide mapping of the terms used to describe technologies could enrich this reflection.
There is also the question of the relationships between the 8 characteristics identified in this study. Do they have causal relationships? Which ones? Answering these questions would help guide their implementation.
Finally, in order to equip ergonomists wishing to contribute to the development of low-tech artefacts, this study was followed by an investigation of user problems with the aim of proposing design principles for low-techs (Colin & Martin, 2023).

CONCLUSION

This cartography leads us to affirm that low-techs are not reserved to engineering sciences and that humanities, and particularly ergonomics, are legitimate and competent in this area. Indeed, low-techs require a technical transformation but also a human and social one (psychological change, usefulness, autonomy, accessibility, usability, controllability, etc.), for which ergonomics is well-suited. Low-techs are also relevant objects of study for ergonomics because they allow us to adopt a critical approach of technology. Finally, working on low-techs is a way for ergonomics to position itself as a more important actor of the technical culture, to contribute to a transition towards a world that is more respectful of humans and their environment by offering a credible and alternative vision to that of green growth.

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