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A framework for the integration of the conviviality concept in the design process

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ABSTRACT

Although the impact of technology on society has been widely studied in the literature, few studies have proposed a practical approach directly engaging stakeholders, including designers and engineers, in the development of new products and services. Within the degrowth movement, some approaches criticizing the western model of development suggest original criteria that could be integrated in the design process.

The current study seeks to analyze the conviviality concept of Ivan Illich (1973) to develop a new framework for designers. To that end, current design literature and four industrial case studies were analyzed according to the five main threats to conviviality: the biological degradation of the ecosystem, radical monopoly, over-programming, polarization, and obsolescence. As a result, this paper proposes a framework that includes two guidelines: one for product scope and another for the socio-technical system scope. The guidelines are composed of a set of recommendations that emerge from the relationship between the threats to conviviality and life cycle stages of a product or service.

These recommendations allow designers and engineers to better approach the complexity of the design process and co-create a strong sustainable society with stakeholders.

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1. Introduction

Sustainability aims to meet the needs of an organization's stakeholders without compromising its ability to meet the needs of future stakeholders, such as companies, citizens, and social organizations (Colvin et al., 2014). To achieve this goal, it is necessary to reduce the current consumption levels and overcome an economy of growth.

A future degrowth society will require the development of new products, services, or uses within the framework of an eco-innovation process, integrating environmental and societal approaches. One major determinant of eco-innovation is technology, providing stakeholders with new cleaner production processes and new green materials, in addition to making information available to manage sustainable uses and behavior. Therefore, the eco-innovation process often consists of integrating such new technologies in industrial systems in order to design new eco-innovative products and services with lower environmental and

societal impacts.

Nowadays, systems are complex and composed of various interconnected elements from economic, social, and environmental fields. Technology cannot be considered sustainable by itself, but must be considered an element of “sustainable socio-technical systems” (Gaziulusoy et al., 2013). To contribute to a sustainable and degrowth society, one must consider the whole system. New technological developments must not be disconnected from the whole system but must consider the added value as well as the undesired side-effects that the final product or service will provide to the society.

Because of its multi-dimensional aspect (Flipo, 2007; Demaria et al., 2013), degrowth is a relevant approach to considering technology as one element in a complex system. Degrowth relates to downscaling production and consumption, with the aims of reducing ecological impacts and improving human well-being (Schneider et al., 2010). Between production and consumption are products and services and the way products and services are designed and used (Spangenberg et al., 2010). Therefore, in line with Latouche (2004), one major issue for designers is the process of designing and selecting “technical innovations”. Designers

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translate technological innovations into fashionable consumer goods (Fuad-Luke, 2005). They are core stakeholders, deeply implicated in mass production, generating negative social or environmental impacts. They participate in a “junk production” process, which is to say, a trivialization of innovation dealing with technological artifice, fashion, and denial of needs (Ariès, 2007).

This is why the contribution of design is required to achieve sustainability in terms of production and consumption (Spangenberg et al., 2010). According to Shove (2003), what is normal and ordinary, especially the routine behaviors of users, has greater importance in building a sustainable system than extraordinary objects and new technologies introduced in the market. Through appropriate choice and implementation of new technologies in products during the production process, design can widely influence consumers and users.

Although the impact of technology on society is a strong topic in literature related to degrowth (Schumacher, 1973; Ellul, 1977; Illich, 1973), the key role of engineers and designers is underappreciated and neglected within the degrowth debate. Consequently, research conducted to date does not provide practical insights into how technologies can be considered in the design process with a degrowth perspective. The conviviality approach is a promising way to rethink the way designers and engineers design products, services, and associated technologies. Illich used the term “conviviality” to “designate the opposite of industrial productivity” (Illich, 1973, p17). In particular, Illich’s alternative to current design is design that focuses on social solidarity, based on friendship and mutual giving, but is also “creatively accepting” its limits (Mitcham, 2003, p29). Therefore, an innovative perspective for designers is not to imagine how to produce and consume less, but rather to innovate on new productive models to overcome capitalist models (Kostakis et al., 2015). In line with this perspective, Poplow and Dobler (2015) recently discussed the “Design for degrowth”, which is concerned less with consumption and more with reproduction, reduction, and relationships. In other words, such design is focused on a reduction of material goods and on an increase of relationship between actors.

Through case studies on companies related to bicycles, the current study questions technology from a design process perspective. As a result, this paper proposes to investigate the benefits of integrating conviviality thinking into the design process of new products and services, in order to enrich current design practices. The resulting guidelines will favor the dissemination of convivial products and services in routine practices.

This paper is divided as follows: Section 2 describes the five areas that Illich (1973) characterized as the main threats to conviviality. A literature review was carried out for each of the five areas, merging Illich’s vision with theoretical concepts and insights from the eco-design literature. Section 3 presents the epistemological position of the authors and the research method followed in the current paper. Section 4 analyzes four industrial cases and describes the conviviality requirements for the design process. Finally, based on the literature review and the findings from the case study analysis, Section 5 introduces a design guideline to integrate conviviality in design process.

2. Theoretical background: an analysis of current design tools and methods through a conviviality framework

Various design tools and methods have been developed to help designers meet sustainability targets (Birch et al., 2012). Although there are no real tools or methods that directly deal with the conviviality concept, the following literature review summarizes a list of approaches and methods that partially integrate elements of conviviality.

2.1. The five threats to conviviality

Conviviality is about living in accordance with a system that satisfies human needs through the contributions of autonomous individuals, rather than with the principles of industrial society (Illich, 1973). According to Illich, society is faced with multiple limits and a natural scale beyond which tools¹ do not serve individuals, but rather serve an unstable industrial system.

Between an under- and an over-industrialized civilization, Illich defines the characteristics of a society of technological maturity. While an under-industrialized society invites the enslavement of man by man, the over-industrialized society enslaves people by its tools (Illich, 1974a).

Therefore, Illich (1973) characterizes six main threats of the overgrowth of tools, which are beyond the boundaries of and incompatible with a sustainable society: (1) biological degradation, (2) radical monopoly, (3) over-programming, (4) polarization, (5) obsolescence, and (6) frustration caused by realization of several of the threats simultaneously.

In the next subsection, the first five threats are analyzed. The sixth threat, related to frustration, is not considered, as it is not an empirical criterion. The connections of the first five threats with existing design tools and approaches are discussed. Some of these approaches warn about these threats, others propose solutions to re-establish the balance disturbed by these threats and finally, some enhance certain of these threats.

2.1.1. Counteracting the biological degradation threat in the design process

The degradation of the ecosystem is a well-known threat in the literature, therefore many design tools have been developed to avoid this threat. These tools primarily come from the eco-design and eco-innovation community. Briefly, these tools are based on life cycle thinking, which considers the products or services throughout their entire life cycle (extraction of raw materials, manufacturing, distribution, usage, and end-of-life), and multi-criteria thinking, which considers the complexity of the environment through different environmental impacts (ISO 14062, 2002). These tools allow designers to significantly reduce the ecological footprint of products, limiting the risk of environmental impact transfer. Other tools, such as the Consequential Life Cycle Assessment (CLCA) go beyond integrating economic notions in the environmental assessment of products and services, and reveal “valuable information regarding rebound effects” (Earles and Halog, 2011, p448).

Specific tools focus on a more innovative approach to sustainable design (Fussler and James, 1996; Tyl et al., 2014), which explores new ways to design radical products and services with the potential of reducing their environmental impacts.

Some recent approaches highlight the integration of stakeholder views into the front end of the eco-innovation process (Tyl et al., 2015b). For example, Bocken et al. (2013) proposed a tool to help designers consider the value captured by different stakeholders in social, environmental, and economic spheres.

In a strong sustainability approach, Bocken and Short (2016) identified new sustainable business models which reduce consumption and which are based on the notion of sufficiency,

¹ Please note that in this study, we distinguish between two types of “tools”:

- “Tools” from Illich’s perspective, i.e., a means of production or offering services, including public services, health, education, transport, etc.
- “Design tools”, i.e., hardware and software for supporting design, based on a design approach, method, or set of guidelines (Blessing and Chakrabarti, 2009).

encouraging consumers to make more with less.

2.1.2. Counteracting the radical monopoly threat in the design process

When people expect something “better”, “easier”, or “more innovative” using a new system based on expertise and centralized tools, “authentic activity” is abandoned. When the balance between “what people need to do by themselves and what they need to obtain ready-made” is broken, a radical monopoly appears and “imposes consumption of a standard product that only large institutions can provide” (Illich, 1973, p63). The result is not only that native capacity to respond to their own needs is perturbed, but also that radical monopolies create dependence on affluence. Examples of radical monopolies include modern medical systems or cars: Current medical systems are based on doctors’ control rather than people’s natural capability to take care of themselves and people in need (Illich, 1974b). Motor vehicle traffic has become a radical monopoly in most of the cities, restraining the right to walk, ride a bicycle, or play in front of people’s homes (Illich, 1974a, p17).

Some recent studies on design proposed solutions to partially overcome this threat by focusing on local skills. Melles et al. (2011) suggested a design process where product and services are manufactured and maintained by end user communities. Manzini (2006) introduced the notion of sustainable systems characterized by low material-energy intensity and a high degree of context quality, i.e., “it has to be tailored to fit the specific characteristics of the local context”.

However, these approaches lack pragmatic and easy-to-use tools to help designers. Moreover, even if they consider the balance between industrial production processes and non-industrial activities, they do not specifically handle the threat of radical monopoly.

Other eco-design approaches such as Product Service System principle (PSS) can be a solution to limit the risk of radical monopoly. PSS is an integrated system of products, services, and socio-economical stakeholders (Tan, 2010) and proposes a switch from the ownership logic to a “sharing and servitization” logic. Nevertheless, PSSs are not inherently sustainable (Dewberry et al., 2013) and can be in conflict with Illich’s warning of radical monopoly, intensifying the necessity for more products and services.

2.1.3. Counteracting the over-programming threat in the design process

Over-programming occurs when the balance of learning is threatened. This balance considers knowledge acquired by “creative action of people” and knowledge acquired through formal education processes. Therefore, the over-programming threat relates to how users can have access to tools for self-initiated learning and be creative when they use a product or service, rather than a “programmed training” (Illich, 1973, p68). Libraries and fab labs² are a good example of convivial tools that allow self-initiated education. Moreover, involvement in a work practice, politics, or leisure activities can also be part of the education and be in balance with formal learning. As an example, specific technology for house building could allow self-assembly of dwellings and at the same time support learning about new materials, instruments, and techniques.

According to Borgmann (2009), current products reduce the engagement of the user, by focusing on the performance linked to their main function and exclude the user from usage or maintenance aspects. The results are “black-box” products, unable to offer

autonomous production of use-values (Maycroft, 2004). Users are no longer concerned with how the product completes the required function and are unable to perform minimal repairs.

The balance of learning is weakly integrated in design tools. Some eco-design tools deal not only with the object, but also with user experience and behavior (Lilley, 2009; Lockton et al., 2008). Above all, the aim of these tools is to reduce the environmental impacts of the product.

The slow design approach (Fuad-Luke, 2005) also proposes a solution to over-programming. Slow design reveals the experiences in everyday life collaboratively in an open-source environment, relying on transparency of information. Moreover, designers must encourage users to become active participants in the design process, “embracing ideas of conviviality and exchange to foster social accountability and enhance communities” (Strauss and Fuad-Luke, 2008, p6).

2.1.4. Counteracting the polarization threat in the design process

Polarization occurs when power is unequally divided and when the number of underprivileged people increases (Illich, 1973, p80).

Polarization is a result of the current economy, structured around large-scale and centralized production units that increase the vulnerability of “decentralized” populations (Johansson et al., 2005).

Some design approaches integrate the notion of distributed production as a new strategy against mass production, proposing new decentralized production and consumption patterns (Kohtala, 2015). Indeed, the concept of “distributed economies” promotes small-scale production, with a local supply chain of socio-economic actors, and uses local resources according to local needs (Johansson et al., 2005). Therefore, this design approach increases the share of added value benefits retained in territories (Mirata et al., 2005).

Measures focusing on power distribution are rarely integrated in design tools. The United Nations Environment Programme (UNEP) guidelines proposed a practical approach to integrating social criteria in the design process, such as working conditions, basic health services, and gender equality (UNEP, 2009).

Another approach to overcome polarization of the economy is frugal innovation (Radjou et al., 2012). Frugal engineering refers to affordable value solutions (product, services, or business models) that meet the needs of resource-constrained customers (in terms of technology, finance, or materials) (Hossain et al., 2016).

2.1.5. Counteracting the obsolescence threat in the design process

Obsolescence threatens the balance between tradition and change (Illich, 1973, p86). The current trend with companies is to stimulate the replacement of products through innovation strategies, resulting in an “engineered obsolescence” (Illich, 1973, p90). Other strategies are to hinder the possibility of self-repair by definitive assembly or specialized tools (e.g., dedicated software for automotive diagnostics) to accelerate the renewal of artifacts (physical products) even if they are repairable (Tyl et al., 2015a). Moreover, it is well-known by the design community that some products are designed according to a so-called ‘planned obsolescence’, due to advances in technology or changes in legislation (Bakker et al., 2014).

Preventing obsolescence is a core concept in eco-design, mainly focusing on durability and reparability of products (Brezet, 1997). Durability means the optimization of lifetime while reparability is the property of a product to be restored.

Some design tools and approaches focus on the management of different “end-of-life options” for a product to overcome this threat. Among these approaches are the reuse, remanufacturing, and upgradability of products. Pialot et al. (2012) defined these three approaches as follows: reuse is the process of collecting used products

² A Fablab, short for Fabrication Laboratory, is a public space equipped with fabrication tools where people share knowledge and create objects for themselves.

or components and distributing or selling them as used; remanufacturing consists of collecting a used product or component, assessing its condition, and replacing broken or obsolete parts with new or refurbished parts; upgradability involves improving a product step by step with the integration of upgrades (Pialot et al., 2012).

2.2. Interrelating the five threats through a systemic design approach

Illich described the five threats in interrelated categories (Illich, 1973, p58). A systemic design approach should be developed to consider a product (or a technology) as an element of a socio-technical system. Such an approach limits the risk of developing short-term solutions that would shift the problem elsewhere in the system (Ehrenfeld, 2008). It allows to take into account the rebound effect and other externalities to reduce environmental and social impacts (Santarius, 2016). Therefore, new approaches have emerged based on a more systemic vision, integrating all dimensions of sustainability (Gaziulusoy and Brezet, 2015) and, consequently, they can integrate several threats to conviviality, arising from the fact that the five threats are interrelated. They focus on the integration of technology in design processes within a systemic and global thinking system. Gaziulusoy et al. (2013) developed a vision to link a company's product development level with a macro-societal transformation to achieve sustainability. Cucuzzella and De Coninck (2008) also recognized the design process as a holistic practice where designers create life-styles rather than products, and therefore can persuade users to reconsider current unsustainable modes of living and propose alternative sustainable solutions incorporating different stakeholder visions.

A solution to avoid the five interrelated threats is the critical scale of tools (Illich, 1973). Within these boundaries, Illich calls for the use of "convivial tools", which can empower users, give them the opportunity to self-learn and keep the balance between self- and ready-made work, and between human activities and the biosphere.

In line with Illich, Kohr (1976) discussed the "diseconomies of scale" to argue that beyond a critical size, "the homogenous society" fails, and this overgrowth leads to a dysfunctional society. Closely related to the concept of convivial tools, Schumacher (1973) defined the concept of "intermediate technologies", which are tools based on traditional knowledge that can be acquired or easily created by a majority of people. Intermediate technology looks for a reasonable productivity somewhere in-between traditional and modern technology, by favoring labor-intensive rather than capital-intensive technology. Therefore, a low-income person should be able to acquire and use this technology without having the expertise and a specialized raw material supply. Moreover, the technology should be designed in a way to be easily maintained and repaired by every person.

In line with intermediate technology, Schumacher (1973) suggested a "regional approach" to create a decentralized production that responds to local needs based principally on local materials. The local criteria (Kurland et al., 2013) and re-localization measures (Latouche, 2004) are key elements of the degrowth strategy and have been primarily explored in economics. For example, Frankova and Johanisova (2012) discussed the concept of "economic localization". Through an analysis of the work of several authors, they defined "economic localization" as, the "support of as many localized aspects of production and consumption as possible" (Frankova and Johanisova, 2012, p307). Emergent design approaches are in line with this idea and focus on local products, skills, and resources. Melles et al. (2011) proposed "socially responsible design" as a way

of designing "solutions" using existing or new skills and workmanship. To do so, various criteria should be integrated in the design process including "relative affordability" (is the outcome locally and regionally affordable?), advancement (does it create local or regional jobs and develop new skills?), local control (can the solution be understood, controlled, and maintained locally?), and empowerment (does it empower the community to develop and own the solution?). Moreover, Lucca (2010) outlined ways of integrating socio-ethical and sustainable approaches with industrial design. Based on an interdisciplinary perspective, Lucca (2010) claims that design must promote local skills, environmental humanization, suitable technologies, participation, and inclusion of local resources.

2.3. Synthesis

The reviewed design tools and approaches do not completely cover all of the threats to conviviality. Even if eco-design tools have allowed designers to significantly reduce the ecological footprint of products, they have led designers to technology-oriented solutions, such as changing materials or reducing packaging. Therefore, designers fail to reach a systemic vision of the way products and services are produced and consumed, generally restricting the vision of the rebound effect to the transfer between environmental impacts.

In the same way, the integration of the social criteria in the design process rarely focus on the structural problem of power distribution. Indeed, some social measures can make outcomes more equally distributed, but they can also claim a maximization of these outcomes, calling for more industrialization. Uncontrolled industrialization is one of the main causes of polarization, and in order to balance power, industrial activities should decrease on behalf of non-industrial activities.

Additionally, the design approaches that focus on the management of different "end-of-life options", consider the optimization of the product's lifetime. However, they do not contest the obsolescence of traditional techniques and therefore do not specifically handle the threat of obsolescence.

In conclusion, each of the threats defines a limit beyond which a balance is disturbed: balance between human activities and integrity of the biosphere, balance between native capacity and institutionalization, balance between formal education and authentic learning processes, balance between traditional techniques and industrialization, and balance between "good" and "better" (Illich, 1973, p88). The design tools and approaches that optimize only one of the threats to conviviality will unavoidably generate rebound effects. It is necessary to consider all these limits at the early phases of the design process and restrain the scale of the designed sociotechnical systems in order to maintain those five balances.

The aim of the current study is to define new approaches to support the design of new products and services from a conviviality perspective. This study raises the following research question: "How can designers integrate conviviality in their design process?" Through a literature review and in-depth analyses of four organizations, this study proposes a framework to support designers in integrating conviviality in their designs.

3. Epistemological framing, research process, and case study

This section presents the epistemological position of the authors and the methods used in the current study.

The epistemological framing applied in this research is based on an epistemology of complexity (Maturana and Varela, 1980; Morin, 1990; Le Moigne, 1994). The design of a sustainable socio-technical

system is considered a complex process, so the generation of knowledge from the materialization of the process should not be separated from the different acts in the process.

The first principle adopted in this study is a pragmatic approach to research (Le Moigne, 1994) focusing on the generation of actionable knowledge, i.e., knowledge that is helpful in solving pragmatic problems (Argyris and Schön, 1996). The theory of complexity proposes new ways of understanding the processes where the researcher's goal is not only to describe future socio-technical systems, but also to understand the system by changing it. In other words, on the one hand, researchers are active actors of the design process and on the other hand, they learn from the system in progress (Maturana and Varela, 1980; Morin, 1990). Therefore, design research focuses not only on the development of novel concepts and design tools, but also on their experimentation in the real world (Horváth, 2007) as described in Subsection 3.2. The second principle adopted in the current study is that researchers must contribute to the sustainability of the systems in which they have been involved (Manzini, 2009).

3.1. Research process

A qualitative method based on a multi-case study approach was employed for the current study. This study aims to develop a new understanding of overcoming different threats to conviviality in the design process and generate a usable guideline for practitioners.

The research process is composed of three steps. The first step consists of in-depth interviews with stakeholders of four enterprises from the same industrial sector. These interviews have been consolidated with additional sources of data described in Table 1. The second step is a critical analysis of the interviews within a conviviality framework. In the third step, a guideline is developed to support designers in counteracting threats to conviviality in their design process.

3.2. A multi-case and engaged participatory action research approach

The research method relies on a multi-case approach based on a well-known product within the degrowth community, the bicycle. The case studies cover a wide spectrum of the bicycle value chain: a manufacturer, an automatic electric bicycle sharing system, a specialist of urban logistic systems, and a bicycle repair workshop (also called bike kitchen).

The case study approach was chosen in this study in order to get data from a real-world setting. Indeed, the case study approach is well-recognized because it can provide researchers and practitioners with relevant information for exploratory research (Blessing and Chakrabarti, 2009).

The authors followed an action research process to develop the case study approach. The action research process aims to generate knowledge while simultaneously trying to find solutions to problems (Lewin, 1947; Rispol, 2002; Coughlan and Coughlan, 2002).

In this study, researchers were particularly involved, as co-developers, in two different case studies more as actors than as

observers. Therefore, the study should be considered as an engaged or a participatory action research. According to Van de Ven and Johnson (2006, p803), in this approach “researchers and practitioners co-produce knowledge that can advance theory and practice in a given domain”. Therefore, authors do not claim to obtain general results, but rather contextual results for a specific situation (Laperche and Picard, 2013).

3.3. Main characteristics of the organizations studied

This section describes four case studies. The bicycle industry was chosen due to both authors' personal engagement to promote and develop a mobility system based on bicycles. Therefore, the personal engagement justifies that all of the selected organizations come from the same region.

The objective was to select complementary organizations with different levels of technology integration. To do so, three main criteria for the selection were adopted: (1) the availability of the data for the different case studies, (2) the type of final product provided by the organization to cover the different practices related to the bicycle sector, and (3) the size and maturity of the company.

3.3.1. Wecoop – electric bicycle sharing system

Wecoop is a technology-based start-up founded in 2014 as a limited company, which currently has four employees. The company designs integrated electric bicycle sharing systems for both public entities (i.e., municipalities) and private organizations. The objective is to promote alternative solutions of sustainable mobility for short urban trips.

One strategy of Wecoop is to propose open-source solutions, so that the source code of the software and the hardware developed for the system is publicly available.

The authors benefited from various informal discussions with the founder as well as other formal discussions regarding common participation in the projects. Moreover, one in-depth interview directly related to the study was conducted with the founder of the company.

3.3.2. E1 – high quality bicycle manufacturer

E1 is a worldwide European bicycle manufacturer created in the 19th century and structured as a producer co-operative. It employs 120 workers, who are also the owners of the company.

The company designs and produces bicycles for both competition and leisure. For example, in the competition sector, E1's bicycles are used by riders in the Tour de France and by the world champions of mountain biking. In the leisure sector, E1 markets different types of bicycles, ranging from children's bicycles to electric bicycles.

One in-depth interview was conducted with the head designer of the company. In addition to this interview, the authors had various informal discussions with different employees of the company over the last eight years.

3.3.3. EVOLO – three-wheeled electric bicycles

EVOLO is a three-wheeled electric bicycle manufacturer

Table 1
Main characteristics of case studies.

Organization	Participatory research	Main source of data	Additional source of data
Wecoop	No	3-h interview with the entrepreneur	Informal discussion with the entrepreneur and authors' personal knowledge
E1	No	3-h interview with the head designer	Informal discussion with various employees the last eight years
EVOLO	Yes	Authors' personal knowledge	Previous interviews with the entrepreneur, analyzed in (Real et al., 2013)
Txirind'Ola	Yes	3-h interview with two members Authors' personal knowledge	Discussion with various members of the association

founded in 2009 and currently has nine employees. Previously structured as a producer co-operative owned by the workers, EVOLO has recently changed its status to a limited company in order to collect more venture capital to invest in a higher manufacturing capacity.

The company strategy is to propose urban mobility solutions, especially in urban freight mobility. It designs, manufactures, and commercializes three-wheeled electric bicycles for logistics activities.

The analysis of EVOLO was performed through a participatory research action, as one of the authors is deeply involved in the company as a co-founder. The analyzed elements materialized from the experiences of the involved author were systematically assessed by the second author, in order to avoid bias due to misinterpreting his own experiences.

3.3.4. Association Txirind'Ola – bicycle repair workshop

Txirind'Ola is a self-help bicycle repair workshop founded in 2011 and a member of the French "Heureux Cyclage" network, which promotes and valorizes the activities of self-help bicycle workshops in France. The association was supported by more than 1000 members in 2015 and is managed by 10 active volunteer-workers and two employees. The main goals of this association are to promote bicycle usage, reduce pollution and waste, and enhance a do-it-yourself attitude. Such repair workshops have recently been studied by the degrowth research community (Bradley, 2016).

One in-depth interview was conducted with two volunteers who actively participate in the technical tasks of the association. Moreover, in line with EVOLO, the analysis of the Txirind'Ola bicycle repair workshop was performed through a participatory research action, as both authors are co-founders of the association.

3.4. Data collection and analysis

Different sources of information were analyzed for these four case studies. The first source of information were three in-depth interviews with one designer or entrepreneur, conducted during the second half of 2015.

These interviews, each of which lasted for approximately 3 h, were divided into four parts, and all the questions were designed to evaluate how threats to conviviality could be overcome in the design process. These interviews were recorded in French. A verbatim transcription of relevant parts of the interviews was done and no specific software was used to prepare the data.

In the first part of the interview, the main activity of the company was analyzed, as well as how the company is related to the bicycle sector. In the second part, the details of the design process were described. In particular, the life cycle of its activity was discussed, from materials extraction to product manufacturing, usage, and end-of-life. The objective was to better understand the main decisions and difficulties of the organization along the entire life cycle of the product. In the third part, the business model of the company was described. Finally, the last part of the interview consisted of an open question concerning the role of the designer or the entrepreneur in the degrowth movement. These interviews were performed for the Wecoop, E1, and Txirind'Ola cases. In the case of Txirind'Ola, as both authors are members of the organization, an external researcher was asked to participate in the interview.

A second source of information comes from the participatory research (for EVOLO and Txirind'Ola). In such cases, the authors had access to their personal knowledge of the organization as well as different internal documents.

The last source of information was provided by various informal

discussions with different stakeholders of the four organizations as well as formal discussions within the framework of collaborative development of projects and previous interviews that lasted for approximately 6 h (for EVOLO). However, no transcription was performed from these discussions.

The following table provides the main information concerning the data collection of the different cases studies.

After collecting all qualitative data, the two authors were independently involved in the analysis of the data. To do so, the authors first independently extracted the main relevant information from the different sources of data and organized them according to the threats of conviviality. No specific software was used to analyze the data. A discussion of the results followed in order to obtain a common view for each case study.

The analysis was combined with the literature review described in Section 2. As a result, a design guideline was proposed to help designers and engineers to integrate a conviviality perspective in their process.

4. Exploratory studies based on four organizations from the bicycle sector

This section presents the analysis of the qualitative data collected for each case study. First, a synthesis of the design process is presented. Next, the main threats to conviviality related to the case study are discussed.

4.1. Wecoop

Wecoop proposes to its customers (public or private entities) an electric bicycle-sharing system to improve the use of bicycles for small urban trips. The final product is based both on a customized electric bicycle-sharing system and an integrated service platform adapted to each context of use. Therefore, the design process of Wecoop is characterized by the integration of two new technologies to a basic bicycle: the electric subsystem, to reduce the effort of the user during an urban trip, and the bicycle-sharing system based on information and communication technology, offering new services such as the improvement of maintenance activities.

During the design process, the main criterion for Wecoop was to develop products that improve sharing practices between users, focusing on the following goals: (1) The sharing of the bicycle itself, to give the user access to mobility without being the owner of the product; (2) The sharing of infrastructure, in order to transfer the automatic checkout stations from one geographical zone to another. An example of this is transferring bicycle equipment from school zones during the school year to beach zones during the summer; (3) The sharing of the technology, to make the source code and hardware design publicly available. Consequently, the design solution is not retained by the company, but rather is open to the community. The customer is free to modify or develop new solutions that will be shared with other users. Moreover, the customer keeps the autonomy to subcontract the services related to the usage and maintenance. It is therefore free to outsource these services to Wecoop, to a local stakeholder, or to perform it internally.

The development of a sharing system for bicycles is linked to the threat of **biological degradation**. On the one hand, the solution proposed by Wecoop requires electronic devices and data centers, which generate major environmental impacts. On the other hand, such a system leads to the optimization of the usage intensity of a bicycle and therefore to a potential reduction of the resource consumption (Mont, 2002). Indeed, as each bicycle is used by several customers, the total number of products is reduced.

While other solutions of competitors are based on an ownership

license, which proposes customized systems and prevents the ability to make improvements or adaptations, Wecoop offers open-source solutions to its customers. Customers have access to a product that can be adapted and they are involved in the development and implementation of the system. Therefore, this system reduces the threat of **over-programming**. The system improves self-initiated learning through a real engagement with the customer and enhances creativity. Moreover, the open-source approach is a relevant solution to prevent the **obsolescence** threat, in particular to prevent the obsolescence of the software used by the system.

A third relevant point of this case study is related to the information and communication technology (ICT) sector. Several technologies have become dominant in this sector (for example the use of Internet of Things technologies). Through the choice of the open-source technology, Wecoop develops solutions that are supported not only by industrial stakeholders, but also by the open-source community. This new constraint in the design process limits the risk of **radical monopoly**, proposing alternative technologies. Nevertheless, the choice to use information and communication technology (through, for example, the use of sensors to collect and exchange users' data) for the sharing system can serve as a new centralized tool as well as a new standard, and consequently a potential threat.

Finally, Wecoop's competitors are multi-national companies connected to the advertisement sector (for example JCDecaux®). The company must define its strategy, in terms of partnership, with these powerful stakeholders to avoid a **polarization** threat, and this decision will influence its up-scaling strategy and also the possibility to counterbalance the power of multi-nationals.

4.2. Company E1

E1 designs and produces bicycles for both competition and leisure. The company's design process is characterized by two recent changes. The first change was the modification of the product design scope, moving from bicycle design and manufacturing to bicycle assembly. The second was the emergence and dissemination of carbon composite technology,³ which became the main technology used by the company. These two changes had major impacts on the design and manufacturing process, as well as on the stakeholder ecosystem of the company.

First, because of the modification of the product design scope, E1 has become an assembly-oriented bicycle producer, widely dependent on components manufacturers. Indeed, the bicycle components market is currently controlled by a few suppliers that support most bicycle manufacturers. Instead of designing a new bicycle with specific components, E1 is now contingent on the new component models provided by suppliers, so consequently the company must adapt its design process to the characteristics of the supplied components.

Second, from a manufacturing point of view, E1 manufactured all the modules of the bicycle until the 1970s. Until 2005, several assembly lines remained in Europe before outsourcing most of the production activities to Asia. Therefore, the manufacturing system of E1 was organized to customize bicycles according to factors such as the size of the user and the color of the bicycle, among others.

³ Carbon composite technology encompasses techniques, materials, and processes to produce carbon fiber-reinforced plastic parts. This reinforced plastic is a composite material made from carbon fibre and a resin. The production of these materials is controlled by large corporations. The industrial processes to manufacture parts made from this composite are very different from metallic manufacturing processes, which require different skills and different industrial equipment.

The E1 case study is linked to the **radical monopoly** threat, which has emerged in the bicycle manufacturing sector. In order to improve user experience and to reduce bicycle weight, the company adopted several technological innovations, including carbon composite technology, mainly to manufacture carbon fiber-reinforced plastic bicycle frames. As a consequence, this choice restricted the capacity of E1 to customize the bicycles, to produce locally and to maintain the know-how of the manufacturing processes. The artisanal manufacturing system declined and the radical monopoly emerged. This monopoly is not related to a specific supplier, but to a technology that E1 continued to massively use.

A second threat is **biological degradation**. The use of carbon composite technology raises many questions throughout its life cycle. The choice to use this technology results in higher environmental impacts, in particular for the end-of-life of bicycles as this material is not recyclable.

A third threat that has not been controlled by E1 is **polarization**. As a producer co-operative, all of the means of production are owned by employees. Nevertheless, the choice of carbon composite technology and moving from bicycle design and manufacturing to bicycle assembly has caused uncontrolled industrialization. Manufacturing means were transferred to larger non-cooperative manufacturers. As a consequence, a power-balanced supply chain based on co-operatives and small local suppliers was transformed into a power concentrated supply chain, where production is controlled by large and powerful companies. Even if E1 is still a producer co-operative, the main tasks are no longer related to the manufacturing process but to marketing and supplier management activities.

Finally, the use and dissemination of carbon fiber technology strongly limits the possibility for the end-user to adapt or self-repair the bicycle and leads to an **overprogramming** threat. Consequently, this technology also limits the ability to extend the lifespan of the bicycle, leading to the threat of **obsolescence** as it requires specific manufacturing tools and knowledge. The E1 case study also underlines the risk of neglecting traditional manufacturing practices, as the use of carbon technology removes the use of traditional jobs (for example, building steel bicycle frames).

4.3. EVOLO company

EVOLO develops, manufactures, and markets specialized three-wheeled electric bicycles for urban settings. The company's design and manufacturing process is characterized by two key concepts. First, EVOLO cannot produce more than 1000 vehicles per year. Second, the design process does not only focus on the design of products, but also on the design of an alternative urban logistic system for the delivery of packages in city centers. The logistic services are designed in collaboration with local carriers in various European cities. In collaboration with local carriers, the company studies the characteristics of the city, future urban development, and the potential evolution of logistics activities.

From the product point of view, the development of a specialized small-scale production system has specific characteristics: The supply chain of EVOLO is mainly supported by local manufacturers and suppliers within a geographical radius of less than 100 km. Moreover, the company changed the suppliers for two modules of the product (the motor and electronic parts) in 2013, in order to work with a supplier closer to the final assembly line. Even if these changes were not motivated by environmental concerns, EVOLO clearly underlines its interest in integrating local suppliers. More specifically, the company selected a local producer of the electric parts that was more reactive and had shorter delivery times, in

order to facilitate the development of new functions into the product. With regards to the motor, a European supplier offered a more reliable product, which was therefore judged to be less expensive than an Asian product.

City logistics systems and freight policies are based on delivery trucks to develop commercial activities in city centers. Consequently, there is an overgrowth of freight delivery trucks in the city center, leading to environmental and social damage. The existing logistics system has become a radical monopoly and there has been no alternative to deliver packages. Solutions based on freight-carrying three-wheeled bicycles, conversion of streets into pedestrian zones or the establishment of constraints for delivery trucks, such as forbidden streets or restricted delivery time-windows, help overcome the **radical monopoly** threat.

Moreover, replacing delivery trucks by small scale vehicles operating at a limited speed prevents the **biological degradation** threat. Nevertheless, using only the electric bicycles generate environmental impacts during the whole life cycle of the electric sub-system (motor, battery, and electronic parts). This impact includes the end-of-life phase, mainly for the batteries, which are rapidly **obsolescent** due to limited recharge cycles and are difficult to recycle.

The three-wheeled bicycles can also reduce the threat of **over-programming**. In fact, several customers of EVOLO are unemployed people willing to create their own enterprise. This kind of bicycle can be seen as a tool to launch its own activity, learning from a work practice. Creativity of entrepreneurs is limitless as indicated by numerous demands that EVOLO has for specific bicycles (ice-cream selling, different types of waste collect, moving snack, etc.).

This case study is also interesting to analyze with regard to the **polarization** threat from a distributed production point of view and ownership concern. The company has controlled this threat through the development of a local supply chain. Modifications to the supply chain have decreased economic power concentration, moving from a large Asian supplier to a European SME (small and medium-sized enterprise). Moreover, each time that EVOLO has a market opportunity in a non-European region, the company's strategy is to transfer manufacturing activities to this region. Indeed, local industries are better placed to understand the needs of local customers depending on the usage, culture, customs, and other relevant characteristics of each region.

However, the company's status modification has also affected the democratic control of the firm. In a limited company, the power of each shareholder depends on the quantity of shares, while in the cooperative model decision power is equally distributed among the members. This modification was accomplished in order to collect more capital to invest in a higher manufacturing capacity, which raises the question of the optimum manufacturing capacity to remain convivial. Nevertheless, other co-operatives in the region have progressively invested in a higher manufacturing capacity taking into account their financial possibilities and without abandoning the co-operative status. Even if EVOLO's new manufacturing facilities are considered as small-scale, the rapid change has caused a company status modification. As a result, workers are not owners of the manufacturing means anymore and there is a risk of uncontrolled industrialization because new investors can decide to increase the industrial capacity further or modify the manufacturing transfer strategy.

4.4. Txirrind'Ola

Txirrind'Ola is a self-help bicycle repair workshop. The organization is not directly concerned with new product design and manufacturing process. Rather, Txirrind'Ola offers assistance to its

members to repair their bicycles and sells repaired products. Therefore, members of this workshop have strong skills and receive relevant feedback for the bicycle design.

Txirrind'Ola considers durability and reparability as crucial criteria for the design of a bicycle. These two criteria depend on the materials, assembly techniques, and correct dimensioning of different components. According to the members of this organization, the production technology should facilitate the further disassembly process and should use ordinary assembly techniques. Lastly, from a materials point of view, steel parts are easier to repair than plastic, carbon composite or aluminum parts.

Bicycle repair workshops are interesting cases for analyzing how the car-based **radical monopoly** can be overcome. These kinds of organizations are considered by public entities as crucial agents to encourage urban bicycling. Active members of Txirrind'Ola have a systemic view of their activities and as with many bicycle repair workshops, Txirrind'Ola encourages bicycle usage through many activities, including bicycle-riding courses, bicycle safety campaigns, and lobbying for bicycle-oriented urban planning.

Therefore, the practices of Txirrind'Ola offer insights on how to counteract the threat of polarization. It proposes a small bicycle repair unit, at a low price, to give a majority of citizens an access to a bicycle.

The **over-programming** threat can also be analyzed through the Txirrind'Ola case study. The bicycle repair workshop is a place to share tools and knowledge, and create new interactions between members, in line with the do-it-yourself movement (fab labs etc.). People are re-empowered and become more autonomous and creative in the workshop. In terms of design, the workshop allows its members to assess different manufacturing and assembly technologies and choose easily repairable and customizable bicycles.

In conclusion, Txirrind'Ola is a relevant case to analyze the **obsolescence** threat linked to bicycle production. This repair workshop underlines that many bicycle models often break down in the same way. Mass production tends to optimize the cost of each component by making these components more breakable. Txirrind'Ola is an interesting laboratory of design criteria for durability and reparability. Traditional manufacturing and assembly technologies are rediscovered, highlighting the idea that some of these techniques, materials, and skills should be kept in upcoming bicycle developments. In line with this analysis, this case also overcomes the **biological degradation** threat, as it limits the extraction of metals to manufacture the product and it also limits the environmental impact of end-of-life of the products.

This case study also underlines the limits of this grassroots initiative, where the number of members in the association is very large. With a large number of members, it is very difficult to develop interactions between members and enhance the members' knowledge. For this reason, Txirrind'Ola is now more perceived as a "classical" workshop proposing a service of repair activity, rather than a grassroots initiative.

5. Towards a design guideline to integrate the conviviality paradigm in current design processes

Based on the analysis of the current design tools, as well as the different practices underlined through in-depth study of the four case studies, this section proposes a framework to integrate conviviality concepts into a design process. Practices and design tools that aim to overcome the threats to conviviality provide insights to develop such a framework, in order to increase the awareness of designers and engineers and complete eco-design guidelines.

First, some recommendations for the products and socio-

technical levels that overcome the five threats to conviviality are presented. Then, two guidelines are proposed (Tables 2 and 3).

5.1. Introduction

To develop the framework, a three-step process has been followed: (1) from the analysis of the current design tools, a first set of recommendations was proposed for different conviviality threats; (2) the analysis of the case studies provided new insights to be integrated in the framework, (3) to make the use of this guideline easier, these recommendations were organized following the product life cycle stages (raw material extraction and processing, manufacturing, use, and end-of-life).

Fig. 1 illustrates the conceptual framework resulting from this research. The framework includes two guidelines composed of a set of recommendations, depending on the goals, the limits of the scope, and the constraints of the engineers and designers. Therefore, the two guidelines correspond to two different scopes, the product scope, and the socio-technical system scope. The former limits the scope to the physical product, which is often the working scope of the designers and engineers. The latter includes a larger scope, which includes the physical product, but also service issues, stakeholders, business models, or socio-political issues. Within this scope, the individual elements of the system were not analyzed separately. Instead, the system was studied as a whole and sustainability was studied as a system property.

5.2. Development of the guidelines

As previously discussed, **biological degradation** has been widely studied in design literature. The main approach is eco-design, involving life cycle and multi-criteria thinking, and taking into account rebound effects. From a more systemic point of view, current approaches to sustainability lead to a sufficiency-based way of thinking to reduce consumption. The case studies underlined that eco-design can lead to a technological approach, such as the use of batteries and ICT systems, but the threat of biological degradation is not overcome with a single technology-oriented solution. A convivial approach favors a low-tech solution in order to reduce the use of materials and minimize the risk of the rebound effect.

As previously stated, the threat of **radical monopoly** comes from a lack of balance between ready-made solutions provided by large institutions and self-made ones. Emerging design literature proposes solutions to avoid this threat and focuses on approaches that include “empowerment” of local actors in the product design

process. Local actors should find their own solution to their own needs. Moreover, literature also shows the limits of the servitization economy and ready-made solution services. The case studies also confirmed this threat. Designers must limit the use of uncontrolled technology (for example the use of specific ICT or the use of specific materials, such as carbon fiber). Moreover, during the design process, designers must ensure that users are given the opportunity to use other technologies if they choose to do so.

The **over-programming** threat involves the creative experience of the user. The literature review showed that some design tools integrate a part of this aspect focusing on users’ experiences and their real needs. Designers often set up usage scenarios where users are conscious of the manner in which the product completes the required functions. In order to promote these practices, the case studies emphasize that technology used for product development should not be under private licenses and copyright. Designers must use technologies that make it easy for an average person to use, maintain, and repair the product with basic skills. Besides, the product should allow the acquisition of more knowledge, which develops user’s know-how. Lastly, if open-source technologies are used for manufacturing and usage stages, the user will be able to share the acquired knowledge with others.

The **polarization** threat means that power between stakeholders is unequally divided. Some design approaches take into account this threat promoting small-scale production and controlled industrialization. The case studies clearly showed the benefits of developing distributed production units, such as small repair units. Through this new model, designers can improve the access to the product for local users. In addition, the case studies also showed the need to choose technology that is not controlled by powerful stakeholders, in order to keep the control of means of production at a local level. One possibility is to guarantee the ownership of the means of production by local stakeholders.

The **obsolescence** threat is widely discussed in the design community. Current eco-design approaches propose some tools to avoid the risk of obsolescence, through durability, remanufacturing, or upgradability principles. The convivial approach also contests the obsolescence of traditional techniques and criticizes the “engineered obsolescence”. The case studies confirmed these recommendations, in particular the interest to integrate open-source strategies (for example to avoid the risk of obsolescence of software). They also showed that designers must focus on durable materials and components, which are easy to repair. Additionally, the case studies emphasized the need to avoid the obsolescence of traditional skills and means of production.

Moreover, the case studies also pointed to the importance of

Table 2

Presents recommendations for the product scope.

Design guideline for the product scope	Life Cycle phase
Is the product designed in order to be adapted to local raw materials?	Raw material extraction and processing
Does the product support the creative process of the users (and other relevant stakeholders) by allowing them to produce their own product?	
Do the producers own the means of production?	Product manufacturing
Can the product be manufactured locally?	
Does the user really need this product?	Use
Can the product be acquired by most of citizens (including low-income people)?	
Is the product designed to last as long as possible?	Use
If the former product is still functional, why does the user want to change it?	
Does the product encourage knowledge acquisition and sharing in the usage phase?	Use
Does the product allow the user to understand how it fulfils the required function?	
Can the product be redistributed and modified/improved without restrictions?	Use
Is the product designed to be repaired and upgraded by an average person?	
Does the product encourage knowledge acquisition and sharing for maintenance and repair?	End-of-life
Can the user perform minimal reparations with standard accessible tools?	

Table 3
Guidelines for the sociotechnical system scope.

Design guidelines for the sociotechnical system scope	Life Cycle phase
Can raw materials be obtained with traditional and simple techniques accessible to an average person and in a sustainable way?	Raw materials extraction and processing Manufacturing
Is the production based on local skills?	
Is the product/innovation's added value shared equally between the stakeholders of the value chain?	Use
Can the product be manufactured using well-known, non-privatized techniques?	
Do materials and characteristics of the product/innovation allow it to be produced with traditional and simple techniques accessible to an average person?	
Can the product be produced in a distributed way (with small scale production units)?	
Does the product/innovation promote a sufficiency-based way of thinking to reduce consumption?	
Is the sociotechnical system accepted and controlled by the users' community?	End-of-life
Does the product/innovation allow users to find a solution adapted to their own needs?	
Does the product/innovation avoid the use of uncontrolled technologies (based on expertise and centralized tools)?	
Does the product/innovation guarantee the user the accessibility to other technologies?	
Can the product be used with local resources (materials, infrastructure, skills, etc.)?	
Is the maintenance based on local skills?	
Can the product be repaired with minimal and simple infrastructure?	
Does the system prevent the obsolescence of each component?	

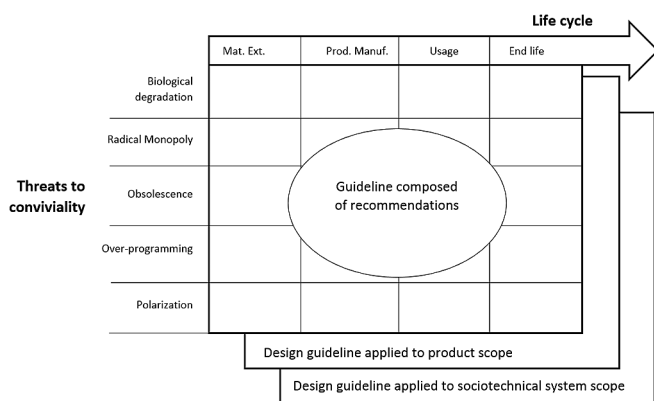


Fig. 1. A conceptual framework for conviviality.

This study analyzes the five main threats to conviviality defined by Ivan Illich (1973): the biological degradation of the ecosystem, radical monopoly, over-programming, polarization, and obsolescence. First, current design literature was analyzed according to these threats. Second, the main threats to conviviality were identified within four different types of organizations in the bicycle sector: a long term established company, a short term established SME, a self-help workshop, and a technology-based start-up.

As a result, this paper proposes a framework that includes two guidelines, one for the product scope and another one for the socio-technical system scope. The guidelines are composed of a set of recommendations that emerged from the relationship between the threats to conviviality and the life cycle stages. These recommendations include criteria rarely considered in the design process, prioritizing users' autonomy and creativity and setting constraints of local production and of the use of local, traditional, and simple techniques.

The framework sets the foundations of a "Design for Conviviality" approach. The objective is to allow designers and engineers to face the complexity of the design process in the transition towards a degrowth society and to co-create a strongly sustainable society with stakeholders.

Some limitations of this study should be highlighted. This study reports on four case studies already involved in a social or environmental approach. Consequently, interviewees were already conscious of sustainability issues such as the reparability of products and mass production, among other issues. However, they do not represent the majority of designers or engineers. In addition, the authors recognize that these case studies were chosen because of their mutual geographical proximity (the Basque country). Consequently, these case studies, and their design process, were embedded in a common local context: common available resources, production system, or environmental and social policies. The geographical proximity raises the question of the influence of this local context on the design process. Furthermore, only one employee per organization was interviewed, so this study presents only a partial view of the organizations.

Two main conclusions may be drawn from this study. First, this study shows that it is necessary to develop a systemic design approach that counteracts the five interrelated threats to conviviality. Through a systemic approach, designers can be aware of the critical scale of the solution they propose, beyond which one or several balances will be disturbed: balance between human activities and integrity of the biosphere, balance between native capacity and institutionalization, balance between formal education

developing a local approach. Taking into account the local criteria adds new constraints into the design process, such as materials, processes, and workforce, which should be locally available along the entire life cycle of the product or service.

Table 3 presents the recommendations for the socio-technical system scope. Within this scope, designers and engineers consider the entire system in which the product is embedded, and therefore they design not only a product but also a wider, holistic system, taking into account the relationship between the elements of the system and the possible rebound effects.

6. Conclusions and perspectives

Current companies are becoming increasingly involved in environmental management systems or corporate social responsibility policies, but these initiatives often lead to negative or limited reduction of the environmental and social impacts (Banerjee, 2008). Moreover, designers and engineers are currently deeply implicated in ecological and social degradation because of the uncontrolled industrialization and junk products consumerism. Some design tools coming from the eco-design community aim to reduce the ecological and social footprint of products, but most of them promote sustainability through short-term solutions. In parallel to this approach, other design tools propose a systemic vision focusing on the whole system and integrating interconnected elements from economic, social, and environmental areas within the design process.

and authentic learning processes, balance in the division of power, and balance between the respect of tradition and its obsolescence.

Second, the conviviality guidelines increase the awareness of designers and engineers and complement existing eco-design guidelines. Small-scale, low-tech, and local criteria enlarge the space of solutions for designers and engineers, completing the dominant trend of over-industrialized high-tech solutions.

Future studies should analyze the influence of the integration of a “Design for Conviviality” approach in current design processes. Indeed, the conviviality guidelines proposed in Section 5 are based on the results of this study. Although these guidelines come from an analysis of real-world case studies, they have not been tested in design workshops. The authors aim to test and improve these guidelines in future research. The objective is to better understand the influence of these guidelines on designing more convivial, innovative, and promising socio-technical systems, as compared with current design tools. To this end, the conviviality guidelines will be tested (1) with industrial designers and engineers with no specific skills in sustainability, (2) with industrial designers and engineers with strong skills in environmental and/or social impacts, and (3) with degrowth activists and practitioners. The results of these tests will provide practical insights for the degrowth community, as well as for sustainable design practitioners.

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