LT4Sustain

Lessons in Low-Tech

A Handbook for Sustainable Education

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low tech + sustainability

LEARNING IN LOW-TECH TO PROMOTE SUSTAINABILITY

LT4SUSTAIN is an Erasmus+ funded transnational project. Our objective is to raise awareness of Low-Tech across society.

Contents

Students will examine the local and global (and glocal) interrelationships between the natural, social, economic, technological, political and cultural systems that allow and hinder the development of sustainable practices. This module places a heavy emphasis on peer discussion and practical work (workshops, case study analysis, etc.).

Design for Sustainability

This module provides learners with a broad understanding of the concept of Low-Tech and its application in the context of sustainability. It aims to equip students with the knowledge and understanding required to assess Low-Tech solutions and evaluate their appropriateness in each context. Further developing the learner's appreciation of Low-Tech solutions from an aesthetic and philosophical context.

Art of Simplicity

The aim of the module is to introduce an open design approach as a design open for studying, modifying and replicating, as well as using and repairing. Such design is also intended to be accessible and inclusive regarding skills and finances. It can be applied to an item, a system, or an organisation to be shared and improved through various community uses and contributions.

Open Design

This module aims to provide learners with a broad understanding of the sustainability concepts of Reliability, Repairability and Resilience within the context of Low-Tech development. It will equip students with the knowledge required to understand, analyse and assess Low-Tech projects and engage with theoretical models of the Three R's.

Design for Resilience, Repairability, Reliability

This module equips engineering students with knowledge for Low-Tech design, focusing on effective, efficient, and sufficient decision support. It covers systemic approaches, addressing complexity and uncertainties, and emphasizes multi-criteria decision making. Students will explore multi-criteria preference modelling to understand decision-making factors in Low-Tech system design.

Trade-offs between Design Objectives

Designers, engineers, and managers have a significant impact on people's well-being and the achievement of sustainable development goals. This is because their work shapes social, cultural, and environmental contexts and relations. Ethical principles and tools are essential to address dilemmas that professionals may encounter. Due to their specific competencies, it is their responsibility to adopt an appropriate ethical reflection.

The Imperative of Responsibility

Low-Tech entrepreneurship represents a paradigm shift, focusing on leveraging simple yet effective solutions to address complex challenges. At its core, Low-Tech entrepreneurship embodies efficiency, affordability, and environmental consciousness, offering a compelling alternative to resource-intensive methods.

Low-Tech Entrepreneurship

This module examines the concept of "Territoire," focusing on the interaction between social and ecological systems within different contexts. Learners will explore interdisciplinary frameworks, including the Low-Tech approach, to understand societal adaptation to environments and emphasise community-based solutions for sustainable development.

Territoire

How to run a low-tech Hackathon

1. Educators can use it as a reference guide when supporting students in their educational journey / project development.

2. Students can use the guide as a reference manual for their assignments/ projects, aiding their development in becoming sustainable professionals with a Low-Tech mindset.

3. Professionals can use the guide as a reference when undertaking projects to inspire more Low-Tech and sustainable practices.

Prologue

We live in a society that increasingly defaults to technology to solve our everyday problems. The world that surrounds us and the products we create and use have become increasingly complex, embedded with electronics and dependent on energy in order to be useful. They are often manufactured using finite resources and materials that are becoming increasingly scarce and the conditions under which they are produced is often made invisible.

This project aims to promote a Low-Tech mindset to future generations and raise awareness of the potential of Low-Tech solutions to everyday problems or activities. It extends beyond the typical understanding of Low-Tech (some of the examples of Low-Tech used in this course may provoke debate) and looks at how Low-Tech thinking can contribute to a more sustainable future for all, and be applied in both developed and developing countries and communities.

Above: The LyteFire Solar Cooker. Julien Lemaistre, Low-tech Lab. June 2021.
https://photo.lowtechlab.org/picture.php?/730/category/47

The LyteFire - Arnaud's solar oven is a model made up of a sensor of 11 m2 of mirrors, which follows the path of the Sun, returns its rays towards the window of a well-insulated steel box, and which can rise quickly at food processing temperatures (up to 250°C in 1 hour of direct sunlight). With this equipment he produces on average 110 to 120 kg of bread per bakery day, and roasts local seeds which serve as a basis for making emblematic products such as savory seeds for aperitifs, coffees without coffee, Norman spices or sweet plates similar to a chocolate bar.

1: What is our view of the Low-Tech approach?

The term "Low-Tech" was coined in opposition to high-tech solutionism and is rooted in a historical techno-critical trend. Here, we restrict ourselves to introducing significant techno-critical authors' literature in the context of the energy and social crises of the 1960s and 70s.

These authors question the nature and place of technology in our societies with the definition of appropriate or intermediate technologies by Ernst Friedrich Schumacher [2], convivial technologies by Ivan Illich [3], autonomous technologies by André Gorz [4], liberating technologies by Murray Bookchin [5], and democratic technologies by Lewis Mumford [6]. These approaches emphasise small-scale production, sufficiency, respect for the environment, the role of labour-work, and above all, the non-neutrality of technology. Low-Tech is now emerging as the heir to these ideas. Still, it must meet the challenges of democratisation (compared to appropriate technologies) without falling into the pitfall of the mass market (compared to frugal innovation) [8]. Today, the Low-Tech movement has to face the challenge of democratisation, particularly compared to appropriate technologies, without falling into the pitfall of the mass market as opposed to frugal innovation.

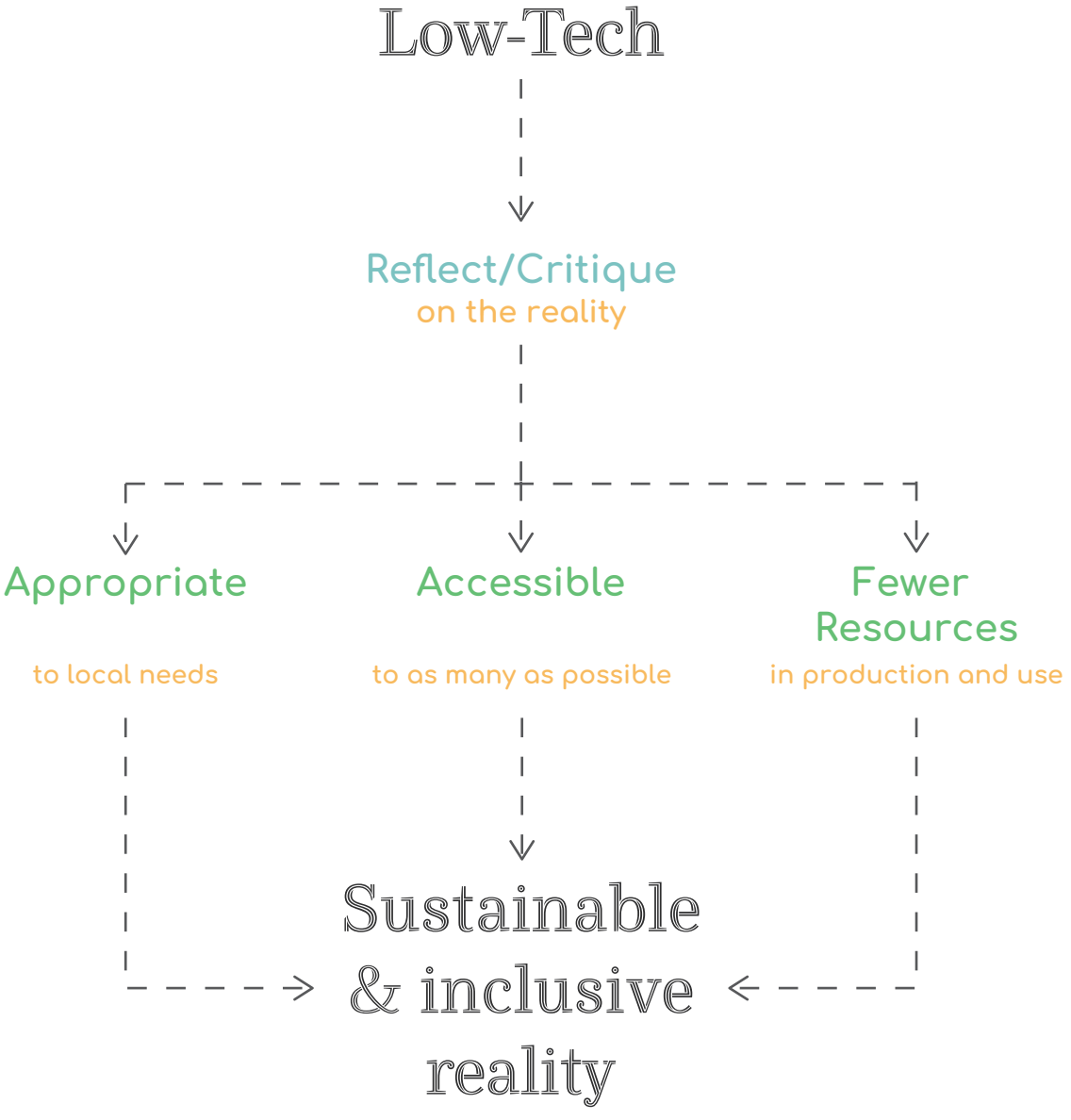
Many authors agree on the difficulty of defining the Low-Tech approach, particularly between the material and political approaches, and given the systemic aspect in the consideration of techniques [14], the variety of definitions of the terms' technique' and 'technology' depending on the discipline [12] or simply the heterogeneity of points of view within this movement [13].

It isn't easy to know where the term Low-Tech was first used. In France, the expression became visible around ten years ago with the creation of the Low-Tech Lab Association in 2013 and the publication of the book L'Âge des Low-Tech by engineer Philippe Bihouix in 2014. Low-Tech was seen as a technical object with attributes similar to those developed in the 1970s: the starting point was a questioning of needs [11], and Low-Tech was a technical response that was [9]:

- Sustainable: systems that are repairable, robust, and modular and limit their ecological, social, or societal impact throughout their life cycle (e.g., use of reusable materials).
- Accessible in terms of cost, resources, and know-how.
- Useful: meeting basic needs, as well as access to energy, food, water, housing, and hygiene. The systems designed encourage the development of a robust technical culture shared by social groups.

Examples of the Low-Tech approach include solar ovens for artisan bakeries and dry toilet collection services to close the nutrient cycle between agriculture and food, as illustrated in two of the Low-Tech Lab surveys. These devices are not just technical solutions, but they also encourage the development of a strong technical culture shared across social groups. In 2022, the French Agency of Transition (ADEME) summarised Low-Tech as an approach rather than a final technical solution [10]. Being relevant and effective in a given context and for given users, this approach must be local and promote autonomy. The Low-Tech approach, therefore, is not just a guarantee of strong sustainability, collective resilience, and cultural transformation but also a beacon of hope and inspiration for a more equitable and sustainable future [15].

The book Perspectives Low-Tech [12] takes a step back from these definitions. Starting with the questions "why-what-how to produce?", the authors point to a significant omission: who is asking these questions, and who is answering them? They invite us to think about "how we can get involved, collectively and democratically, in the technical direction of our societies?". Regarding the useful-sustainable-accessible triptych, they stress that the notion of usefulness and associated needs is challenging to define because it is relative and probably irrelevant when reducing our consumption. They reformulate utility to the idea of sufficiency, which can only be embodied collectively and within planetary limits. They ask the question: "What is sufficient for us to flourish collectively in a constrained world?" and conclude once again by stressing the importance of democracy in our technical choices.


Low-Tech
Reflect/Critique
on the reality
Appropriate
to local needs
Accessible
to as many as possible
Fewer
Resources
in production and use
Sustainable
& inclusive
reality

1: What is our view of the Low-Tech approach?

So, the Low-Tech approach is a long way from technophobia or low cost, which is sometimes confused: it combines considerations of sustainability and equity with a critical look at our technical systems and the social, cultural, and political conditions that gave rise to them.

Based on these various materials and in order to instantiate the Low-Tech definition in our project focused on Higher Education and favouring inclusivity, we defined Low-Tech in LT4Sustain as: We created the infographic in figure 1 [left] to aid the explanation of the fundamental Low-Tech concept.

"A value system to develop a paradigm focused on creating appropriate and accessible solutions that reflect, critique, and generate new approaches to use fewer resources while responding to local needs (simply) to create a more sustainable and inclusive reality."

Suggested additional Reading

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[2]E. F. Schumacher, Small is Beautiful - Economics as if people mattered, HarperCollins. 1973. Accessed: Jun. 14, 2022. [Online]. Available: https://sciencepolicy.colorado.edu/students/envs_5110/small_is_beautiful.pdf

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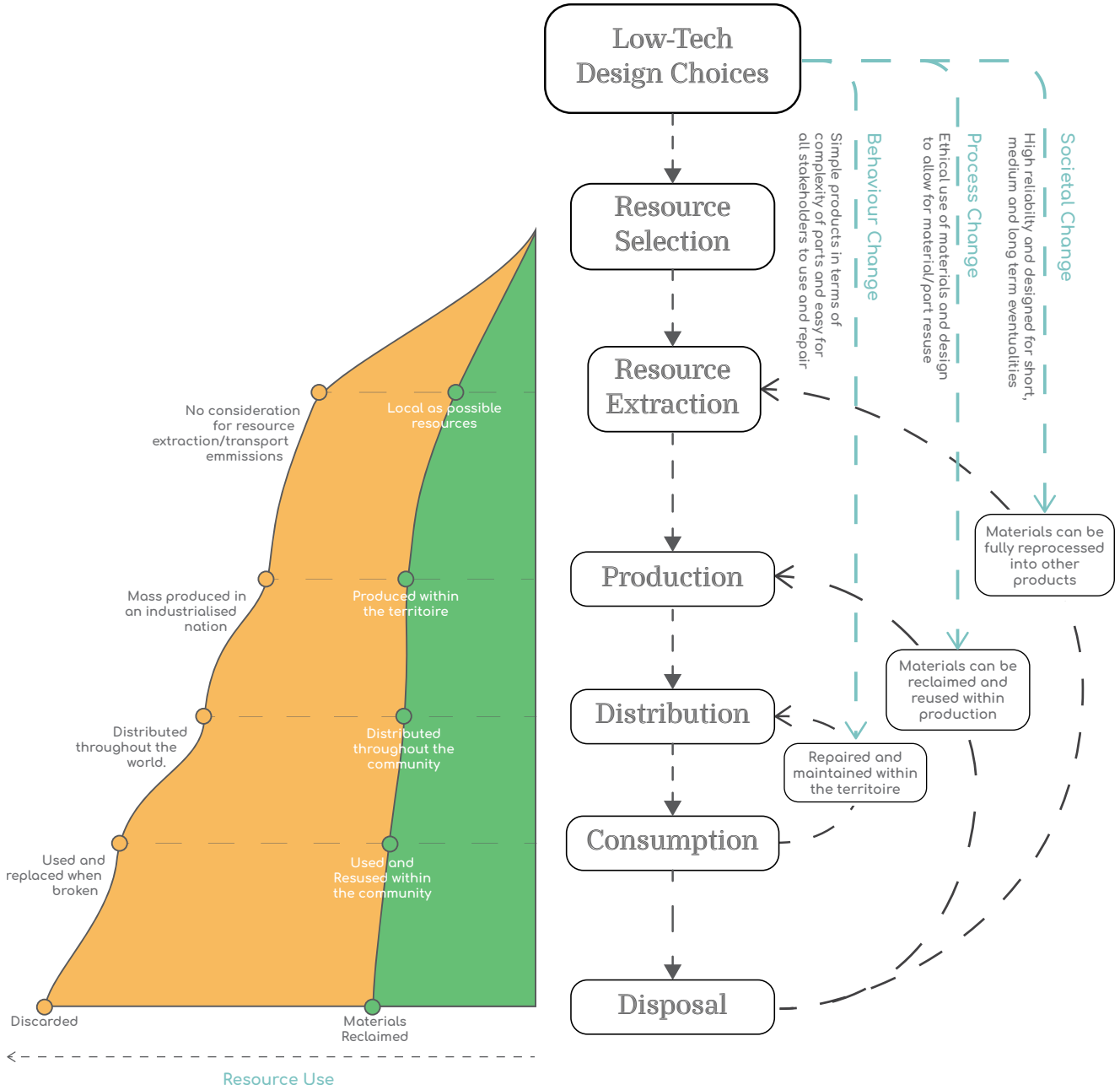
[13]Tanguy, Audrey, Lisa Carrière, and Valérie Laforest. 2023. « Low-tech approaches for sustainability: key principles from the literature and practice ». Sustainability: Science, Practice and Policy 19 (1): 2170143. https://doi.org/10.1080/15487733.2023.2170143

[14]Carrey, Julian, Sébastien Lachaize, et Guillaume Carbou. 2020. « Les low-techs comme objet de recherche scientifique. Vers une société pérenne, équitable et conviviale ». La Pensee ecologique N° 5 (1): 7-7.

[15]Infographic « Low-techs: Sustainably securing the essentials for all » gathering the criteria for any low-tech innovation approach. Arthur Keller and Emilien Bournigal. https://en.wikipedia.org/wiki/Low_technology#/media/File:Low-tech_innovation.jpg



Above: Hendrick, P. Almrott, C. 2024. What are the Systemic Implications of a Low-Tech Model? Technological University Dublin, Dublin. https://doi.org/10.21427/rpex-tx14

1: What is our view of the Low-Tech approach?

What are the Systemic Implications of a Low-Tech Model?

Low-Tech solutions are often undervalued but can be highly innovative and contribute significantly to economic development. Instead of focusing solely on high-tech, research-intensive industries, policymakers should recognise the importance of "Low-Tech" sectors and provide appropriate support.[1]

Low-Tech approaches prioritise simplicity, durability, repairability, and local production, offering a promising alternative to the current focus on efficiency, automation, and globalised supply chains. By embracing these principles, we can establish more sustainable and resilient economic models, decreasing our dependence on resource extraction and global trade.[2]

Shifting from a narrow focus on high-tech solutions to embracing Low-Tech principles like frugality, modularity, and reconnection to local environments could significantly reduce resource consumption and environmental impact, aligning with the need for more sustainable development.[3]

To fully embrace this transition, we need to reevaluate our current policies and indicators that prioritise high-tech industries over Low-Tech ones. We should also introduce legislation and incentives that promote more sustainable Low-Tech approaches to mitigate the effects of planned obsolescence and excessive consumption.[4]

Suggested additional Reading

[1.] Hirsch-Kreinsen, H., Jacobson, D., & Robertson, P. L. (2006). 'Low-tech' Industries: Innovativeness and Development Perspectives—A summary of a European research project. Prometheus, 24(1). https://doi.org/10.1080/08109020600563762

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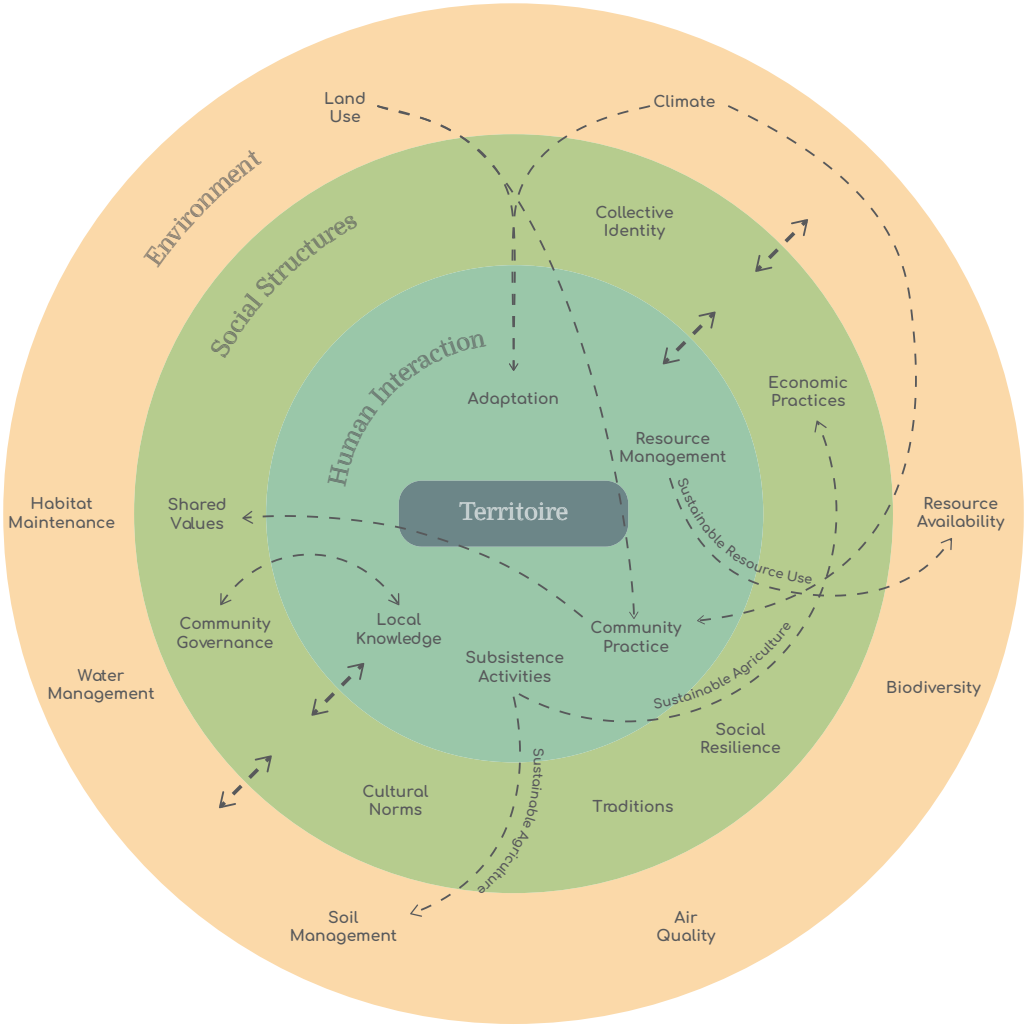


Above: Almrott, C. 2024. What do we mean by Territoire? Technological University Dublin, Dublin. https://doi.org/10.21427/0ag2-a080

1: What is our view of the Low-Tech approach?

What do we mean by territoire?

The concept of "territoire" can be understood as a way to describe the dynamic, interconnected relationship between people and their environment. Unlike "territory," which often implies defined borders and control over land, territoire emphasises the fluid and lived connection between humans and the spaces they inhabit, interact with, and transform. It is about understanding a place not just as a physical location but as a social space shaped by the activities, memories, and identities of those who live within it.

In many ways, territoire serves as both a framework and a lens through which to observe how people adapt and respond to environmental changes. Low-Tech approaches, such as rainwater harvesting, traditional farming methods, or natural building materials, encourage people to adapt to their environment in a way that respects and preserves natural systems rather than attempting to control or dominate them. When applied to territoire, this means that people work with the resources and limitations of their landscape. For example, in times of drought, a Low-Tech response might focus on traditional water conservation techniques, natural irrigation systems, or resilient crop varieties in dry conditions rather than energy-intensive infrastructure. This approach encourages communities to adjust their practices and foster a balanced, respectful interaction with their surroundings.

Territoire also emphasises the social aspect of Low-Tech by recognising that local knowledge, traditions, and social structures are vital components of sustainable adaptation. When communities make decisions about resource use or environmental management, they rely on a shared understanding of their environment that has developed over generations. This local perspective forms the core of Low-Tech thinking: it values small-scale, incremental adjustments based on collective experience and wisdom, making each member of the community feel included and valued rather than large-scale technological interventions.

Ultimately, within a Low-Tech approach, territoire represents not just a space to be managed but a living system that communities actively shape and sustain through careful, context-sensitive practices. It highlights the importance of knowing a place intimately, understanding the unique interactions that make it thrive, and adapting in ways that prioritise harmony with the environment. Through this lens, territoire becomes a blueprint for building resilient, sustainable communities grounded in ecological sensitivity and social cohesion, making us feel connected and responsible for our environment.

“It’s a question of collectively reappropriating needs, asking ourselves together what is really useful and what isn’t”

Quentin Mateus Director of research at the Low-Tech Lab

1: What is our view of the Low-Tech approach?

How to use this book

As an educator...

Most often, when teachers have to design and implement a new course, they can draw on the teachings they have received themselves. Indeed, they will enrich this initial content with more recent knowledge, research, and personal experiences. They will also adapt the overall content to their audience based on an estimated level of initial skills and a desired level of final skills to achieve, as well as considering the socio-cultural developments of their time. However, all of this can start from an analysis and structuring of the study field carried out by their predecessors. Very few of us have received teachings on the Low-Tech paradigm. As this is an emerging subject, it is expected that those wishing to engage may have little formal education in the discipline. It aligns well with contemporary issues. While the principles highlighted may not be necessarily new - interest in resilience, concern for frugality, etc., have already been advocated by previous generations - combining all these aspects into a single paradigm is relatively new, especially when contrasted with a definition of progress focused on technological advancements.

Teachers who want to create a learning framework for the Low-Tech paradigm need help besides teaching content. Traditional (i.e., ex-cathedra) lectures on the content will not suffice, neither for individual content nor for the paradigm as a whole. The framework must involve practical activities since it involves instilling an approach based on a value system.

The fundamental objective of the LT4SUSTAIN project is to provide a learning framework comprising different content modules centred around an implementation event: a hackathon. Thus, teachers can find a toolbox that can be customised here. They can integrate part or all of the proposed content modules into their framework. For each module, they can find prepared content that can be adapted to their specific context.

The hackathon is also presented in the form of a scheme that can be configured based on the context.

While the general principle of a hackathon is relatively well-known, its implementation must carefully activate the principles of the Low-Tech paradigm. Experience shows that learners can function in isolation, separating the hackathon from the principles covered in the content modules. It is, therefore, the responsibility of the teachers to re-emphasise these principles so that they gradually become design and implementation reflexes for the learners. Given the magnitude of the task, the LT4SUSTAIN project has been led by a team of teachers from different backgrounds. This indicates how this project should be implemented in an educational institution. Specifically, it is unrealistic to imagine that a single teacher can handle the entire learning framework. Operating with a team of teachers with various sensitivities or skills will be more effective and relevant.

One last piece of advice? In addition to the content and pedagogical approach, essential questions arise and should be addressed. How do we integrate this into a training curriculum, an institution's functioning, or the overall activities of teaching teams? All these questions (and probably others) can only be answered locally, depending on the context (including the territory), the institution, and available resources. However, one element that must be emphasised is the need to sufficiently involve the institution's authorities in these considerations, as the impacts on learners, teachers, and the institution are significant. And means must be made available to achieve success...

What this framework can offer a student:

This framework is designed to offer accessible and self-explanatory content to undergraduate students, without requiring any specific pre-requisites. The framework offers a comprehensive introduction to the main topics of the Low-Tech paradigm, such as utility, accessibility, and sustainability to help students understand how Low-Tech contributes to sustainable development and societal progress. Additionally, the course helps students understand the teacher's perspective when creating a new Low-Tech curriculum.

By exploring the principles and practices taught, students gain a deeper perspective on the pedagogical objectives and teaching methods associated with the Low-Tech paradigm. Moreover, students have access to various complementary resources, such as articles and case studies, which enable them to deepen their understanding of Low-Tech.

Increasing student autonomy in understanding Low-Tech

A number of strategies can be employed to increase student autonomy in understanding Low-Tech. One effective approach is to create interactive learning modules, which allow students to explore Low-Tech concepts at their own pace. These e-learning modules could feature quizzes, practical exercises, and simulations to make the content more engaging and understandable without requiring the presence of a teacher.

Another useful strategy is to produce explanatory videos that explain the fundamental principles of Low-Tech. Through short, informative videos, students can benefit from practical demonstrations, concrete examples, and animations to help them visualise the concepts.

To encourage peer-to-peer interaction and foster collaborative learning, online forums could be set up where students can ask questions, share ideas, and discuss Low-Tech topics. This can help students better understand the subject matter and learn from each other's experiences.

Finally, providing students access to a diverse range of supplementary resources, such as articles, books, case studies, and recorded lectures, can deepen their understanding of Low-Tech and allow them to explore different perspectives. By offering a wide variety of resources, students can develop a more comprehensive and nuanced understanding of Low-Tech, which can help them to apply these concepts in real-world contexts.

Low-Tech competences	Thinker	Conceiver	Maker	Facilitator	Communicator
Systems thinking	Yes	Yes			Yes
Futures and anticipatory thinking	Yes			Yes	
Values thinking and ethics	Yes				Yes
Strategic thinking	Yes			Yes	
Interpersonal management			Yes	Yes	Yes
Multi-disciplinary problem-solving		Yes	Yes	Yes	
Implementation (Design, Action & Assessment)		Yes	Yes		
Intra-personal competence/Self efficacy	Yes	Yes			
People-centeredness and behavioural change	Yes		Yes	Yes	Yes
Commons management and solution scaling		Yes		Yes	Yes

2: The Educational Model

A comptency framework for learning in Low-Tech

The concept of "Low-Tech," as articulated by Philip Bihouix and others in France, shares parallels with the appropriate technology movement of the 1970s. While the latter focused on developing innovative technologies that were useful, accessible, and durable for developing countries, Low-Tech emphasises applications in developed contexts. Both movements, however, prioritise simplicity, resilience, and sustainability over complexity and excess.

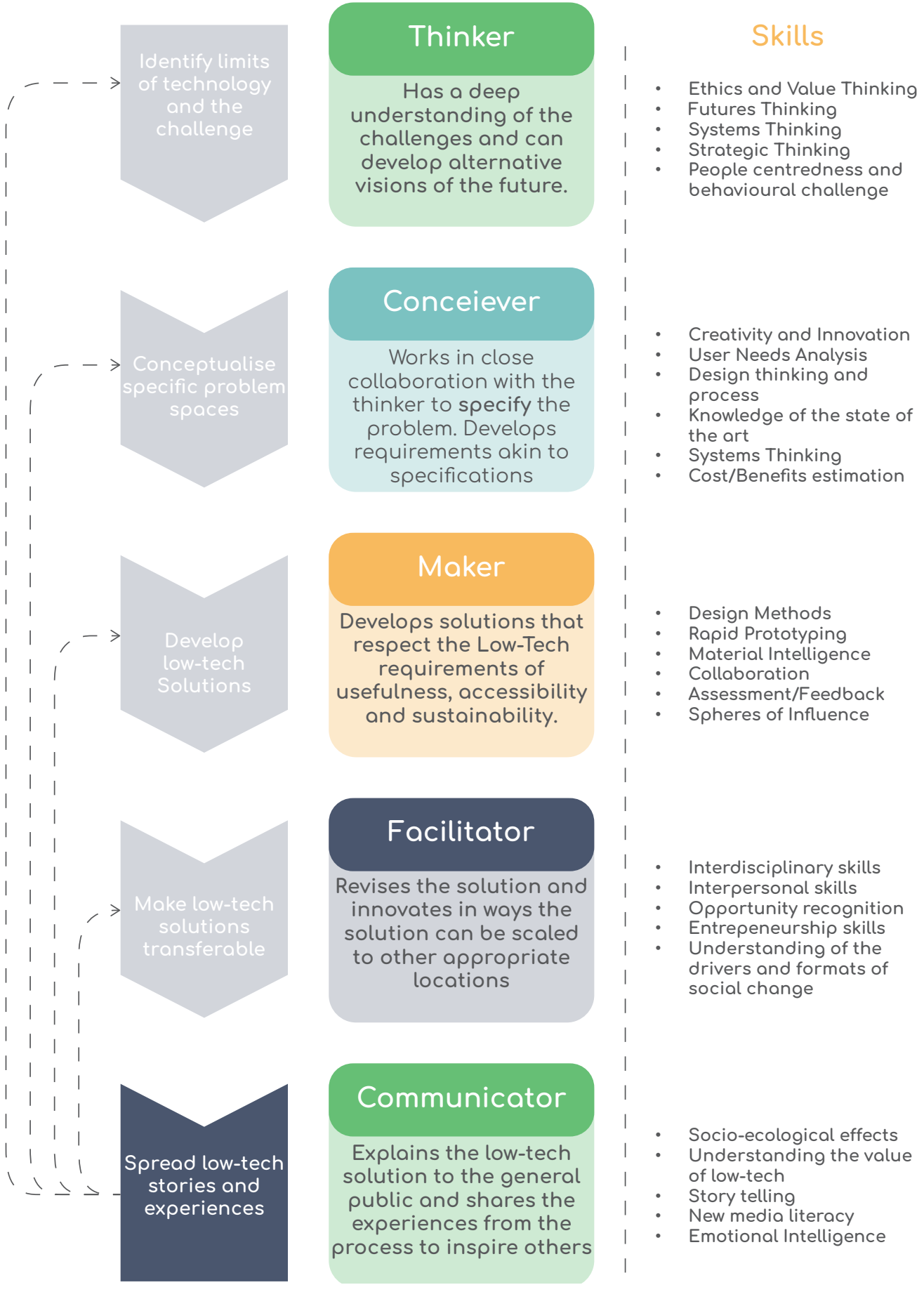
To create a competency framework for Low-Tech, we examined numerous frameworks across sustainability, human-centred design, social innovation, appropriate technology, and open innovation. The EU Joint Research Centre's sustainability competency framework was foundational to our work, offering a comprehensive synthesis of prior research. However, its focus did not fully encompass the accessibility and human-centred ethos integral to Low-Tech practices.

Bridging these gaps required integrating additional frameworks addressing skills and knowledge in social and open innovation. This synthesis merged unique elements, such as; systems thinking, behavioural change, and interdisciplinary problem-solving, into a cohesive Low-Tech competency model.

The result is a unified framework highlighting key roles and their competencies for implementing Low-Tech projects. These roles, while distinct, are fluid, allowing individuals to adopt multiple perspectives throughout a project lifecycle.

The roles within our Low-Tech competency framework represent groupings of complementary competencies, designed to guide the development of Low-Tech projects. These roles: Thinker, Conceiver, Maker, Facilitator, and Communicator, encapsulate distinct yet interconnected skill sets and mindsets that are crucial for addressing complex challenges.

While each role reflects a unique focus, individuals may adopt multiple roles throughout a project, depending on the needs of the task or team dynamics. This flexibility allows for a holistic approach to Low-Tech innovation, fostering collaboration and adaptability.


Identify limits of technology and the challenge
Thinker
Has a deep understanding of the challenges and can develop alternative visions of the future.
Skills
Ethics and Value Thinking
Futures Thinking
Systems Thinking
Strategic Thinking
People centredness and behavioural challenge
Conceptualise specific problem spaces
Conceiever
Works in close collaboration with the thinker to specify the problem. Develops requirements akin to specifications
Creativity and Innovation
User Needs Analysis
Design thinking and process
Knowledge of the state of the art
Systems Thinking
Cost/Benefits estimation
Develop low-tech Solutions
Maker
Develops solutions that respect the Low-Tech requirements of usefulness, accessibility and sustainability.
Design Methods
Rapid Prototyping
Material Intelligence
Collaboration
Assessment/Feedback
Spheres of Influence
Make low-tech solutions transferable
Facilitator
Revises the solution and innovates in ways the solution can be scaled to other appropriate locations
Interdisciplinary skills
Interpersonal skills
Opportunity recognition
Entrepeneurship skills
Understanding of the drivers and formats of social change
Spread low-tech stories and experiences
Communicator
Explains the low-tech solution to the general public and shares the experiences from the process to inspire others
Socio-ecological effects
Understanding the value of low-tech
Story telling
New media literacy
Emotional Intelligence

Defining Competencies

This competency framework outlines the key skills required for working within a Low-Tech design approach, emphasising systems thinking, ethical values, and sustainable problem-solving.

Each competency is defined with clear progression levels, guiding learners from foundational understanding to advanced application across multidisciplinary, human-centred, and context-sensitive domains.

Systems Thinking

Work effectively in their field within a complex system interconnected with society, economy, and environment, while considering various scales from local to global.

- **Level 1:** Identify the contours of the system under study (impacts on planetary limits, impacts on the local economy, on user behaviour, etc.)
- **Level 2:** Understanding and analysing a prospective scenario and its context
- **Level 3**: Have a systemic vision and the ability to analyse critically.

Futures and Anticipatory Thinking

Be able to create and evaluate future scenarios of their field in the view of "low-tech" (sustainability, sober needs, and accessibility) taking into consideration uncertainties and proposed actions

- **Level 1:** Understanding the main scenarios and identifying the levers for change (e.g. green technologies, circular economy, neo-industrialisation)
- **Level 2:** Understanding and analysing a prospective scenario and its context.
- **Level 3:** Create your own prospective scenarios with a strong sustainability approach

Values Thinking and Ethics

Be able to understand the values that cause the actions of various individuals; and be able to negotiate these values and targets in a context of conflicts of interests, uncertain knowledge, and ethics.

- **Level 1:** Identify the ethical dimensions of the designer's work.
- **Level 2:** Understand the importance of ethics in design and take a critical look at the current situation
- **Level 3:** Integrating ethical considerations into the solution and design proces.

Strategic Thinking

Recognise the historical roots and barriers to unsustainability and societal challenges, and creatively plan innovative experiments to test strategies in their field to address these issues.

- **Level 1:** Understand the ecosystem (institutional, legislative, political, economic/commercial, cultural)
- **Level 2:** Identify the obstacles and levers in the ecosystem (administrative, legal, cultural constraints, etc.)
- **Level 3:** Exploit the levers of the ecosystem to ensure the long-term deployment of a Low-Tech project

Interpersonal Management

Be able to apply their competences in ways that engage and motivate other very different people; and to be able to work with others who have different ways of knowing and communication

- **Level 1:** Awareness of the personal characteristics of individuals in a group, positioning your profile in the team
- **Level 2:** Ability to interact with others in the group, help other members to develop personally
- **Level 3:** Ability to take a leading role in the collective development of a group

Multidisciplinary Problem-Solving

Be able to creatively solve problems in their field not only using information from their field, but also information from other fields, and even new ways of thinking and knowing.

- **Level 1:** Framing of the problem in their specialist field
- **Level 2:** Framing the problem with a multidisciplinary approach. Application of knowledge from other fields.
- **Level 3:** Framing complex problems with an interdisciplinary and transdisciplinary approach. Generation, application, synthesis and communication of new knowledge.

Implementation (Design, Action & Evaluation)

Use design thinking in an iterative approach to create impactful solutions and evaluate their effects across economic, social, and environmental domains.

- **Level 1:** Understanding the design thinking approach, its stages and the link between design and sustainability
- **Level 2:** Understand the benefits of the design thinking approach to managing a Low-Tech project
- **Level 3:** Use the design thinking approach for a low-tech approach, while maintaining a critical eye.

Intra-personal Competence / Self-efficacy

Be aware of their emotions, desires, thoughts, and behaviours, and continuously improve themselves using skills from emotional intelligence and social-emotional learning.

- **Level 1:** Awareness of the notion of intra-personal skills (Social skills, empathy, motivation (intrinsic and extrinsic), self-control, self-awareness, values)
- **Level 2:** Understanding the link between their values and their practice as a designer
- **Level 3:** Asserting their role as a designer through their intra-personal skills

People Centredness & Behavioural Change

Able to create and evaluate systems from the perspective of the user, including using appropriate behaviour change techniques.

- **Level 1:** Understanding the concept of sustainable behaviour (voluntary or induced/provoked user behaviour and its importance in the design of a sustainable solution)
- **Level 2:** Study user behaviours to find patterns that can help change those behaviours.
- **Level 3:** Set up a behavioural change model consistent with a low-tech approach and a sustainable goal.

Commons Management and Solutions Scaling

Organise and scale resources for "low-tech" innovations that are accessible, economically viable, and suited to the local context.

- **Level 1:** Knowing and understanding the concepts of scalability, resources and the Commons
- **Level 2:** Adapting to the social, economic and environmental context in which the project is to be located
- **Level 3:** Making the most of the local context to put in place an appropriate low-tech solution under collective management

Defining Roles

Previously in this chapter, we introduced the roles a Low-Tech practitioner. These roles are shaped by a practitioner's ability to navigate complex systems, engage with ethical and sustainable design practices, and create solutions that are accessible, context-sensitive, and human-centred.

These roles highlight the importance of collaboration, critical reflection, and the practical application of Low-Tech principles to address societal, environmental, and economic challenges.

Here, these roles are defined in greater detail to clarify their scope and significance.

The Thinker:

The Thinker is a strategist with expertise in social innovation and systems thinking. They focus on analysing user needs to inspire behavioural change, using a deep understanding of cultural dynamics and fostering self-efficacy. The Thinker envisions desirable futures and develops solutions that align with ethical, cultural, and technological considerations.

Core Attributes:

- Ethics, Territoriality, and Future Thinking: Expertise in social innovation, needs analysis, and envisioning desirable futures.
- Systems Thinking: Proficient in applying systems approaches and understanding complexity science.
- User Needs Analysis: Skilled in identifying and analysing user needs to inform design decisions.
- Technological Awareness: Understanding the relationship between technology and human progress.
- Cultural Awareness: Sensitivity to cultural nuances and their impact on design and behaviour.
- Intrapersonal Competencies: Strong critical thinking and self-knowledge, enabling personal and professional growth.
- People-Centeredness and Behavioural Change: Focused on fostering behavioural change through human-centred strategies.

The Conceiver:

The Conceiver thrives in problem-solving and innovation, leveraging design methods and critical thinking to address user needs ethically. They navigate socio-technical complexities with a deep understanding of technology, systems, and interpersonal dynamics.

Core Attributes:

- Problem Solving: Identifies core problems, assesses user needs, and applies multi-criteria evaluations with ethical consideration.
- Innovation & Creativity: Excels in idea generation, specification development, and critical thinking.
- Design Methods: Proficient in co-design, design thinking, and DFX approaches (e.g., repair, inclusivity, and justice).
- Technological Insight: Understands technological progress, socio-technical systems, and the decision-making processes shaping development.
- System Awareness: Integrates cultural and territorial awareness, systems thinking, and tolerance specification.
- Risk & Benefit Assessment: Evaluates risks and balances costs and benefits beyond financial metrics.
- Interpersonal Dynamics: Manages relationships with emotional intelligence and strong interpersonal skills.

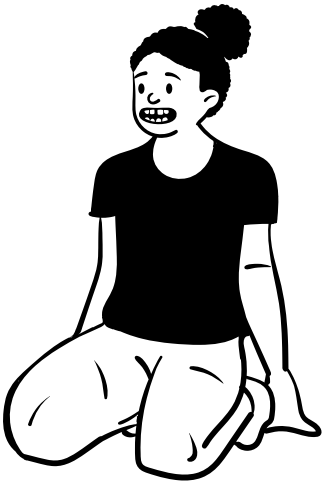
2: The Educational Model

The Maker:

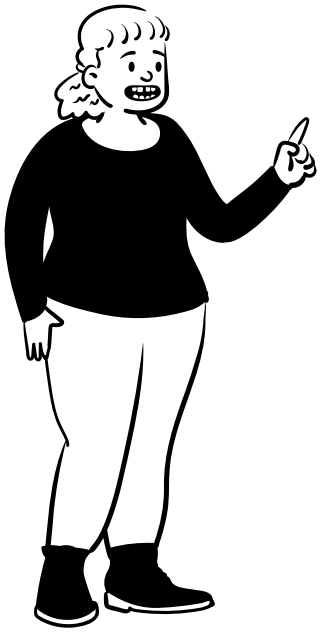
The Maker is a hands-on problem solver who uses design methods and rapid prototyping to create innovative, context-aware solutions. They prioritise appropriate technology, ecological ethics, and interdisciplinary collaboration, fostering partnerships through co-design and collective decision-making.

Core Attributes:

- Design & Prototyping: Rapid iteration, testing, and problem-solving through hands-on methods.
- Appropriate Technology: Thoughtful selection of materials and technologies aligned with ecological and social values.
- Evaluation & Ethics: Balances risk awareness and multi-criteria assessment with a focus on ecological ethics.
- Traditional & Emerging Tools: Incorporates DIY techniques, traditional tools, and digital tools such as 3D printing.
- Cultural & Context Awareness: Designs with sensitivity to cultural and situational contexts
- Collaboration: Utilises co-design methods and thrives in interdisciplinary, cross-functional teams.
- Collective Management: Encourages shared responsibility in technological decision-making.



Illustrations, Open Peeps by Pablo Stanley,
Part of the Open Doodles project. CC0 1.0 DEED.



The Facilitator:

The Facilitator excels in recognising opportunities and future trends, fostering collaboration, and guiding collective decision-making. With strong interpersonal skills and cultural sensitivity, they navigate technological choices and support the replication and scaling of innovative ideas.

Core Attributes:

- Opportunity Recognition: Identifies trends, contextualises insights, and envisions future possibilities.
- Interpersonal & Collaborative: Facilitates idea-sharing, manages collaborative processes, and supports collective decision-making.
- Cultural & Technological Awareness: Balances cultural sensitivities with technological understanding in decision-making.
- Scaling & Replication: Develops strategies for expanding and replicating successful ideas
- Problem Solving: Understands and addresses challenges faced by others.
- Social Innovation: Utilises participative methods, entrepreneurial skills, and social innovation drivers.
- Interdisciplinary Collaboration: Builds cross-domain partnerships and thrives in collaborative environments.

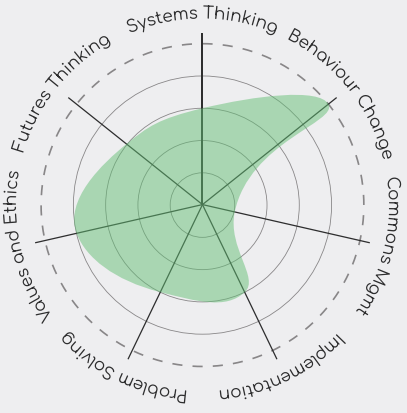
The Communicator:

The Communicator is a skilled storyteller who effectively shares ideas while considering socio-ecological impacts. Drawing inspiration from arts and culture, they encourage open dialogue, critically analyse narratives, and use emotional intelligence to foster understanding.

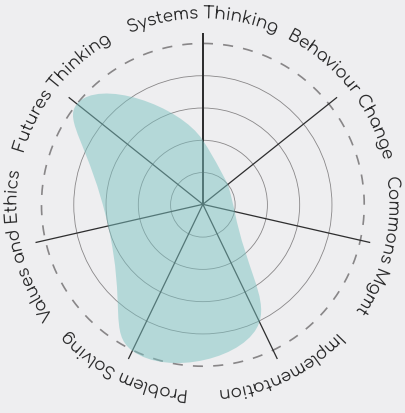
Core Attributes:

- Storytelling & Inspiration: Communicates ideas through compelling narratives inspired by arts and culture.
- Socio-Ecological Awareness: Highlights the value of Low-Tech solutions and their long-term impacts.
- Communication Skills: Proficient in non-violent communication, new media literacy, and multi-directional communication.
- Critical Thinking: Analyses dominant and alternative narratives to challenge perspectives
- Collaboration: Works well in teams, demonstrating cultural awareness and openness
- Knowledge Sharing: Creates open knowledge content to encourage dialogue and understanding.

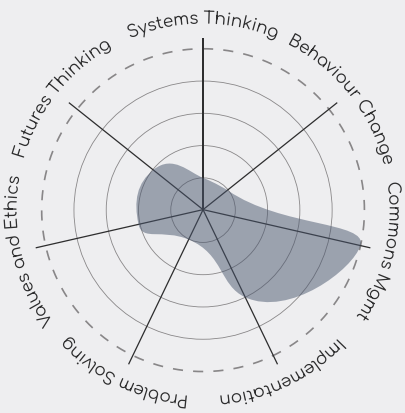
Sustainable Design



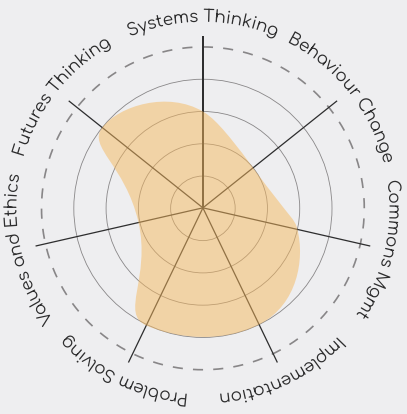
Art of Simplicity



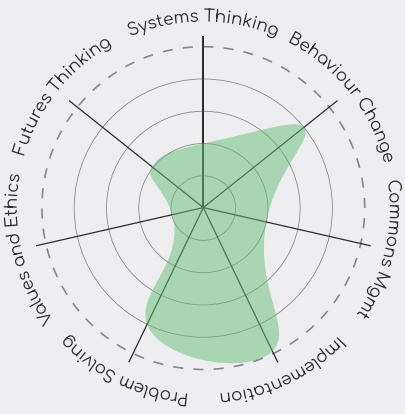
Open Design



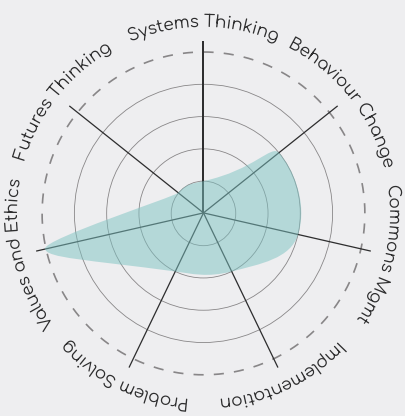
The Three R's



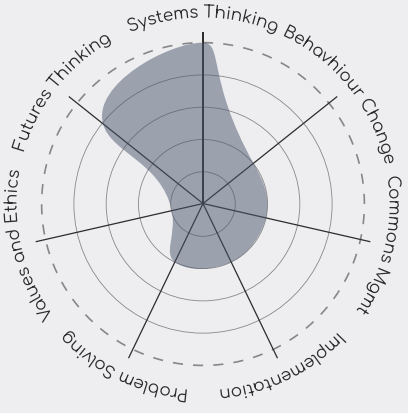
Effectiveness, Efficiencey, Sobriety



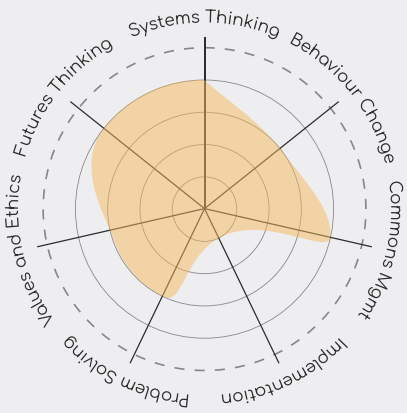
Imperative of Responsibility



Low-Tech Entrepeneurship



Territoire



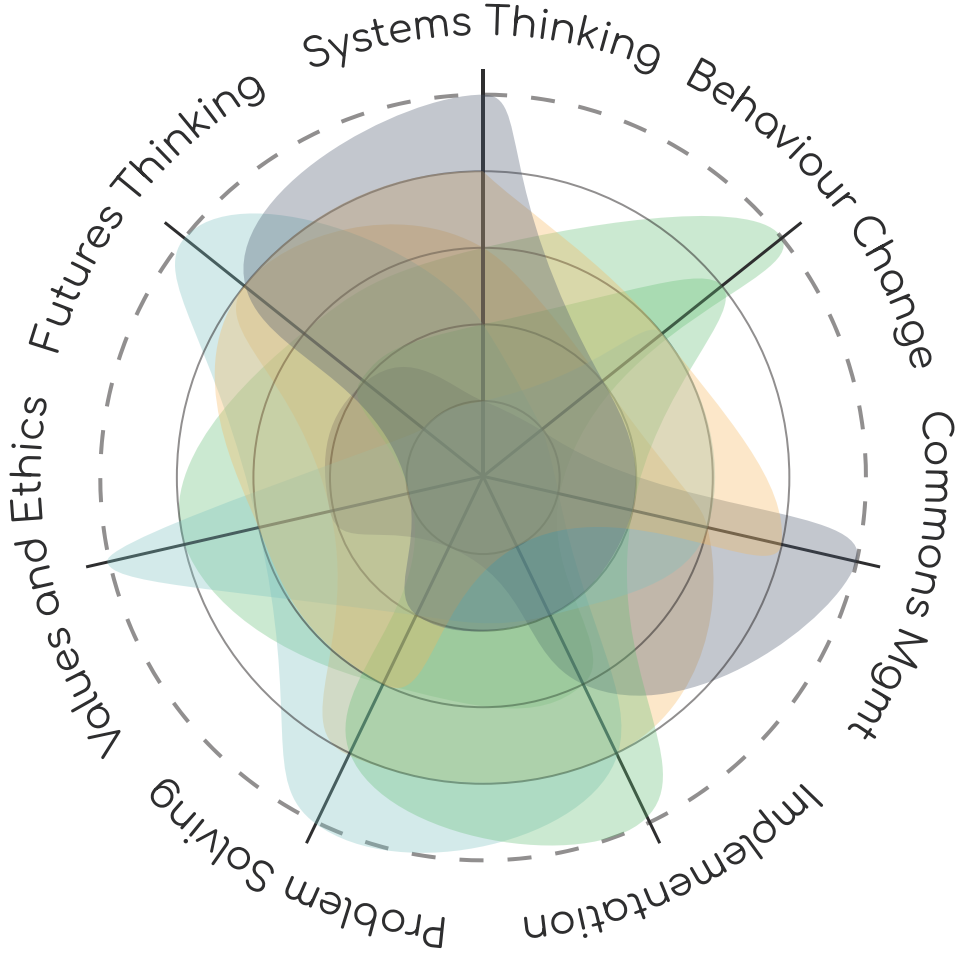
Why these topics?

The LT4Sustain project is aimed at educating students from a broad range of disciplines, including business, engineering, and design, in adopting a Low-Tech mindset. To achieve this goal, the project is structured around eight chapters, each focusing on a distinct aspect of Low-Tech design:

1. Design for Sustainability,
2. The Art of Simplicity,
3. Open Design,
4. Design for Resilience, Repairability, Reliability (The Three R's),
5. Trade-offs between Design Objectives (Effectiveness, Efficiency, Sobriety),
6. The Imperative of Responsibility,
7. Low-Tech Entrepreneurship,
8. Territoire.

These chapters were selected to represent a balanced and interconnected approach to learning the principles of Low-Tech. The radar diagrams on this page, and throughout the book, illustrate the alignment of each chapter with seven core competencies—Systems Thinking, Behaviour Change, Commons Management, Implementation, Problem Solving, Values and Ethics, and Futures Thinking. The visualisations highlight the overlaps and contrasts between chapters, emphasising their interdisciplinary nature. For instance, the strong alignment of "Sustainable Design" with Behaviour Change and Values and Ethics contrasts with the more technical focus of "Implementation" in chapters such as The Three R's. Similarly, the chapters "Open Design" and "Commons Management" demonstrate their shared emphasis on collaborative practices.

These relationships encourage students to view Low-Tech design as a holistic framework, integrating diverse competencies to address complex global challenges. By visualising these interconnections, the diagrams provide a clear rationale for the chosen chapters, preparing students to apply Low-Tech principles in varied contexts and promote sustainable, inclusive futures.



Above: Brent Cheffings, Hackfort. How High Tech and Low Tech are changing the face of politics. March 2019. https://flic.kr/p/2eb3ebb

Why teach Low-Tech?

The inclusion of Low-Tech in education responds directly to the growing demand for transformative and socially relevant teaching. Students are increasingly vocal in their desire for curricula that address socio-environmental challenges, integrate ethical considerations, and offer practical, impactful learning opportunities. Low-Tech education meets these needs by bridging theory and practice, fostering interdisciplinarity, and promoting innovative thinking for sustainable futures.

Low-Tech reveals the material dependencies of our world; resources, energy, and production systems, encouraging critical reflection on how societies interact with technology. This focus makes it a powerful tool for cultivating informed, ethical decision-making, enabling students to question and contribute to the development of resilient and sufficient systems.

By integrating history and ethics of technology, Low-Tech education highlights the social dimensions of innovation. It provides a framework for students to explore the intersection of technical solutions with human needs and planetary limits. Projects in Low-Tech are particularly accessible due to their simplicity and practicality, enabling learners to experiment and create within a supportive environment.

The pedagogical advantages of Low-Tech extend beyond accessibility. By offering "high-knowledge for Low-Tech," students gain advanced insights into fields like permaculture, eco-design, and citizen science while contributing to practical, locally adapted solutions. This emphasis aligns with the open science ethos, allowing students to document and share their findings with broader communities under open licences. Furthermore, the approach fosters creativity within constraints, encouraging learners to tackle challenges using minimal resources while maximising ingenuity.

Examples such as the PISTE semester in Grenoble demonstrate the potential of Low-Tech education to empower students through real-world projects that address societal needs. These projects also expose learners to the complexities of scaling innovations, fostering an understanding of the local and global interdependencies that shape sustainable practices.

Low-Tech approaches nurture a bidirectional relationship between academia and citizens. By addressing the needs of communities rather than purely technological imperatives, Low-Tech promotes a rebalanced approach to innovation, one that values sustainability, inclusivity, and resource efficiency. This paradigm not only equips students with practical skills but also instils a sense of responsibility, preparing them to contribute meaningfully to the creation of equitable and resilient systems

Above: Anna Shvets. Photo of Beautiful Women in White Outfit. June 2020. Pexels. https://www.pexels.com/photo/photo-of-beautiful-women-in-white-outfit-4672288/

3: Inclusivity and Low-Tech

Julie Lhuissier

Inclusivity and accessibility are essential pillars for building a sustainable and equitable future. These principles must be integrated across all aspects of learning, making them a constant consideration throughout the academic journey.

In this section we delve into the complex interplay between inclusivity, accessibility, and the role of Low-Tech solutions in addressing societal challenges. It begins by defining inclusivity as the action of integrating individuals or groups and ending social exclusion[1] , emphasising its fundamental importance in fostering social justice and human rights.

The Low-Tech method aims to offer simple and environmentally adapted solutions to meet the needs of populations. Promoting the use of local resources and simple manufacturing processes makes these solutions affordable and accessible to more people, thus contributing to inclusivity and accessibility. Additionally, by encouraging the autonomy of individuals and communities, Low-Tech strengthens their ability to meet their needs sustainably and resiliently.

In fact, the Low-Tech approach embraces the diversity of the population by offering solutions accessible to all, regardless of their level of technical expertise, available resources, or specific needs. Unlike technosolutionism, which tends to impose uniform solutions, Low-Tech distinguishes itself by its adaptability to individual needs and preferences. Whether by choice or necessity, Low-Tech proposes an adaptable way of life that can be customised according to the circumstances and values of each person. With an emphasis on simplicity, sustainability, and autonomy, Low-Tech provides a flexible framework that encourages the inclusion and engagement of everyone in the pursuit of practical and viable solutions for a more resilient future.

In this module, we have chosen to address the role of Low-Tech in that matter. Indeed, Low-Tech solutions appear as the answer to prevalent disparities that are at the core of systemic inequalities hindering individuals to fully participate in society. Tackling such issues using a low tech approach, generates a possibility to provide simple and accessible solutions to meet the individual and collective needs, thus contributing to greater inclusivity and social equity and equality.

However, an issue arises: Low-Tech solutions are predominantly developed by individuals from the engineering field, mainly by men from higher social classes, who are often white and straight .This situation creates disparities and significantly hinders progress in terms of inclusivity and accessibility.

Ultimately, the text aims to provoke reflection on the complex dynamics between inclusivity, precarity, and Low-Tech methods, advocating for policies and practices that promote social justice, environmental sustainability, and economic resilience. Through analysis and examples, it underscores the immense potential for Low-Tech solutions to not just address various forms of precarity but also to significantly contribute to promoting inclusivity and accessibility, thereby fostering a more equitable and sustainable society.

References and Further Reading:

[1.] inclusivity. (2024). https://dictionary.cambridge.org/fr/dictionnaire/anglais/inclusivity#

[2.] Marosi, N. K., Avraamidou, L., & López, M. L. (2024). Queer individuals' experiences in STEM learning and working environments. Studies in Science Education, 1–39. https://doi.org/10.1080/03057267.2024.2313903

Above: Cliff Booth. Women Sitting on the Couch Chatting. March 2020. Pexels.
https://www.pexels.com/photo/women-sitting-on-the-couch-chatting-4057863/

3: Inclusivity and Low-Tech

Defining Inclusivity

It is crucial to define the term' inclusivity.' Inclusivity, according to a study made by the Department of Philosophy, Sociology, Pedagogy and Applied Psychology at the University of Padua,

"is [...] about focusing on the context and the capabilities our living environments have to allow everyone to actively participate and have a satisfying level of life. Inclusion explicitly considers, with equal emphasis, the right everyone has to receive the attention, flexibility, and adaptations they need"[3].

The concept embodies a fundamental principle of social justice, environmental justice, and human rights. It aims to create environments where everyone is accepted, valued, and fully engaged in social, economic, and political life. Recognising the value of diversity in a community's perspectives, ideas, and experiences underscores its pivotal role in fostering a fair and equitable society. In summary, inclusivity is a cornerstone for achieving equity and equality by promoting access, representation, empowerment, fairness, and social cohesion. By embracing inclusivity as a guiding principle, societies can create more just, equitable, and inclusive environments where all individuals have the opportunity to Wfulfil their potential.

Promoting inclusivity proves crucial in addressing the multifaceted challenges of precarity. Precarity, characterised by instability and uncertainty, manifests in various forms, including digital poverty, economic instability, and energy precarity, among others[4]:

- In France, around 13 million people (~25% of the population), lack internet access, underscoring the issue of digital poverty, especially in rural and disadvantaged areas. This lack of access affects daily lives and worsens inequalities. Implementing inclusive policies can help bridge the digital divide and promote social equity[5].
- An estimated 5 to 8 million people in France face food insecurity, which significantly impacts physical and mental health. Around 14% of the population experiences economic precarity, resulting in social marginalisation. Addressing food security requires inclusive approaches that tackle systemic inequalities and advocate for food justice and equitable distribution.
- Economic precarity affects about 14% of the French population, leading to social marginalisation and economic exclusion. Inclusive economic policies aim to ensure everyone can participate in the economy, promoting equity and reducing disparities.
- Energy poverty occurs when households struggle to meet essential energy needs like heating and lighting. In France, three indicators assess this issue: the energy effort rate affects 2.8 million households, the low-income, high-expenditure indicator impacts 4.3 million, and the discomfort indicator, measuring feelings of cold, affects 1.6 million households. [6].

Defining "inclusivity" within the context of queer individuals adds a crucial dimension to the discussion, particularly within STEM (Science, Technology, Engineering, Mathematics) fields. Inclusivity, as explained by the Department of Philosophy, Sociology, Pedagogy, and Applied Psychology at the University of Padua, extends to actively embracing and valuing the diverse perspectives, identities, and experiences of queer individuals. It involves creating environments where queer individuals feel accepted but also empowered to participate and contribute fully.

By acknowledging the value of diversity in gender and sexual identities within a community, inclusivity serves as a cornerstone for achieving equity and equality for queer individuals. It promotes access to educational and professional opportunities, representation in decision-making processes, and dismantling of discriminatory practices and biases.

Addressing precarity while promoting inclusivity necessitates recognising the specific needs of individuals and communities experiencing various forms of vulnerability. By fostering environments where everyone is included and valued, we can work towards creating fairer and more supportive societies for all.

Accesibility

Inclusivity and accessibility, while often related, are distinct concepts. In contrast to inclusivity, accessibility, according to the French government[7], means enabling the autonomy and participation of people with disabilities by reducing environmental obstacles. This traditional definition focuses primarily on disability and does not consider other groups who may also face barriers in accessing essential resources. For a broader view, the Cambridge Dictionary defines accessibility as the ability to be reached or obtained easily, encompassing a wider range of challenges.[8]

In France, the Law for Equal Rights and Opportunities[9] imposes accessibility requirements on public establishments, transportation, housing, and services. This law also encourages the employment of people with disabilities and their access to education. However, accessibility goes beyond physical infrastructure. Low-tech solutions, designed to be simple, robust, and adaptable to local conditions, offer a promising response to these accessibility challenges. They help overcome physical, organizational, and cultural barriers, making technology accessible to everyone, regardless of their technical skills or resources. By integrating these solutions, we can hope to create more inclusive and accessible environments for all, addressing the diverse needs of our society.

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Above: Inovallée. Juliette Lesne called on the public to help change the way people look at disability. November 2023. Le Dauphine. https://www.ledauphine.com/economie/2023/11/09/pour-recruter-inovallee-propose-la-diversite

3: Inclusivity and Low-Tech

The Role of Low-Tech

So, what is the role of Low-Tech in all of this? This analysis underlines that this approach is comprehensive, aiming to question the prevailing economic, organisational, social, and cultural models. Consequently, it encourages the conception of new consumption, production, and governance patterns. Quentin Mateus states:

"It is misguided to merely seek to replace hightech with Low-Tech out of environmental concern. It is about questioning high-tech and its world."[9]

In this context, Low-Tech represents not only a technological approach but a way of life that challenges contemporary consumption patterns. It promotes simple, sustainable solutions tailored to local needs, challenging modern societies' prevailing logic of overconsumption and waste. Furthermore, the underlying philosophy of Low-Tech questions traditional top-down governance by advocating for a more participatory and inclusive approach. Instead of relying on large, centralised structures, Low-Tech encourages the decentralisation of power and local empowerment to meet essential needs, fostering greater community autonomy and resilience. This challenge to top-down governance aligns with principles of participatory democracy and subsidiarity, where decisions are made at the closest level to citizens, allowing for greater involvement and accountability in managing their own lives and environment. This approach also sheds light on gender biases, as it addresses the disproportionate impact of traditional governance structures on marginalised groups, including women, who often face barriers to participation and decision-making in such systems.

We can further illustrate this through the experience of Félicie Beth, an employee at the Low-Tech Lab in Grenoble. In an interview, she explained the commitment of her male colleagues to establish horizontal governance and to include as many women as possible in the Lab. Despite feeling like an impostor because she was a non-engineer woman, she gradually began to feel more at home thanks to the supportive environment fostered at the Low-Tech Lab in Grenoble.

This demonstrates how Low-Tech challenges traditional consumption patterns and fosters inclusive organisational structures that empower individuals regardless of their background or expertise. However, we can delve deeper by mentioning that she has also expressed interest in activities that focus more on animation than manual work. This raises the question of whether this is related to gender stereotypes or her deep personal preferences.

This reflection highlights that challenges related to inclusivity extend beyond specific domains like engineering or Low-Tech. They can also have subjective impacts on individuals, influencing their career choices and sense of belonging.

Another example is the collaboration between Juliette Lesne, the founder of the "Sous l'capot d'un manchot" association[10], and the Low-Tech lab in Grenoble. Juliette approached the Low-Tech lab to create stage design elements for her theatre company. This partnership showcases how Low-Tech solutions can be inclusive and accessible for individuals with disabilities.

By teaming up with Juliette Lesne, the Low-Tech Lab in Grenoble has demonstrated its dedication to designing environments that meet the needs of people with reduced mobility. In this collaboration, the Low-Tech Lab utilised its expertise in creating simple, adaptable solutions to develop stage design elements that prioritise accessibility. By incorporating Low-Tech principles, such as using locally available materials and considering the target audience's specific needs, the project promotes inclusivity and accessibility. These solutions not only improve the physical accessibility of the environment but also cultivate a sense of belonging and involvement for individuals with disabilities. Furthermore, this partnership underscores the significance of co-creation and community involvement in developing inclusive solutions. By engaging stakeholders with lived experiences of disability, like Juliette Lesne, the Low-Tech Lab ensures that diverse perspectives and priorities shape the design process.

Engineering is a crucial field that uses sciences and mathematics to tackle practical challenges. Although it has historically been viewed as elitist due to rigorous academic requirements, this perception is changing as diversity is recognised as vital. In Europe, access to engineering is significantly affected by socio-economic conditions, leading to notable educational disparities, according to Eurostat.[12],[13].

Despite efforts to increase accessibility in engineering through scholarships and mentorship, inequalities persist, limiting diversity in the field. The Low-Tech movement offers an alternative, but most of its influential figures come from privileged backgrounds with advanced training, raising concerns about inclusivity. In contrast, organisations like the EKO association [14] actively work to democratise access to technology.

EKO collaborates with marginalised communities, including refugees, to create sustainable housing, food security, and energy access solutions. Their open-source approach ensures adaptability to local needs while promoting skills development and community ownership of technological solutions. This holistic strategy addresses immediate issues and fosters long-term resilience in socio-economic challenges. By prioritising inclusivity and empowerment, EKO demonstrates how low-tech innovations can reshape perceptions of technology, paving the way for a more equitable future for all.

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[10.] Mateus, Q. (2023, September 18). Quelle place pour le low-tech dans la société de demain ? Polytechnique Insights. https://www.polytechnique-insights.com/tribunes/societe/quelle-place-pour-le-low-tech-dans-la-societe-de-demain/

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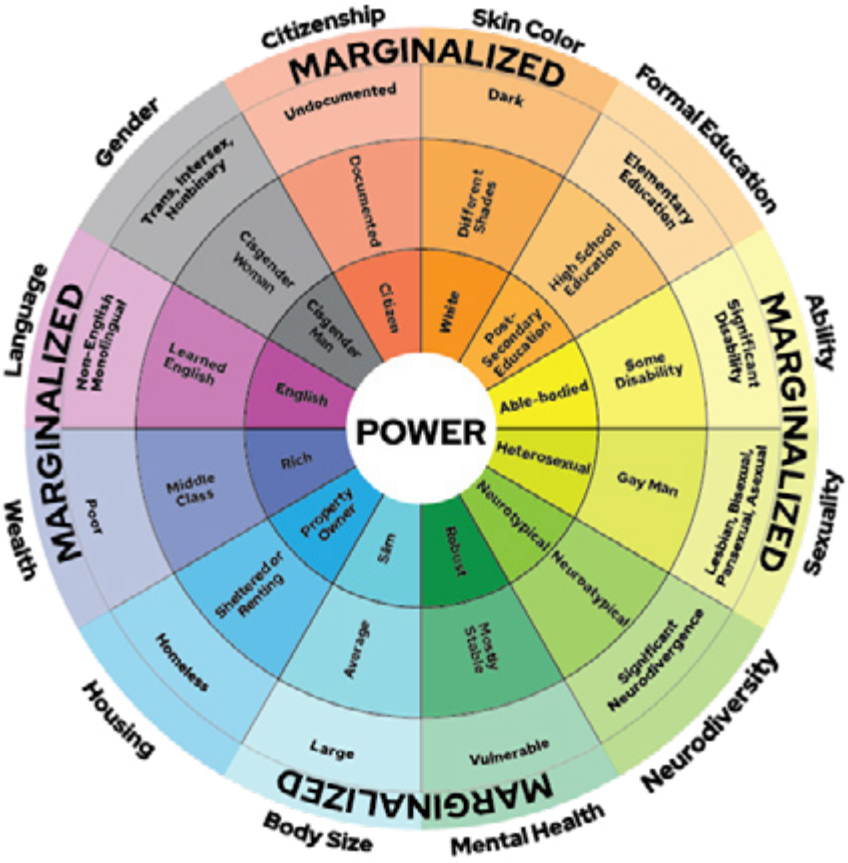


Adapted from James R Vanderwoerd ("Web of Oppression"), and Sylvia Duckworth ("Wheel of Power/Privilege")

Above: Wheel of Power, Privilege, and Marginalization, by Sylvia Duckworth. Used by permission. To our knowledge, the original version comes from the Canadian Council of Refugees (CCR): https://ccrweb.ca/en/anti-oppression. Several versions of the wheel have been developed for various contexts.

3: Inclusivity and Low-Tech

The Limits of Low-Tech

Low-Tech can play a significant role in addressing inclusivity issues related to precarity in France. Low-Tech solutions, designed to be simple, robust, and adaptable to local conditions, offer practical and affordable responses to various forms of precarity, such as energy, food, and housing insecurity. By promoting local employment and encouraging the production, repair, and reuse of goods, Low-Tech approaches contribute to the resilience of communities facing precarity.

However, despite their potential benefits, Low-Tech solutions may have limitations when promoting inclusivity, particularly regarding gender diversity. The engineering field, from which many Low-Tech solutions originate, has historically been male-dominated, presenting barriers to women's participation and representation. Women often encounter discouragement and exclusion from STEM disciplines, perpetuating gender disparities in technology-related sectors.

Throughout history, rigid gender roles and stereotypes have dictated that technical skills are inherently male, leading to an underestimation of women's abilities in STEM fields. Media representations of engineers and scientists as masculine reinforce these stereotypes, further marginalizing women in technology-related industries.

Moreover, institutional biases and inequalities in access to educational and professional opportunities continue to hinder women's participation in Low-Tech sectors. Despite an increase in the percentage of female graduates in core STEM fields, women still represent only a fraction of the engineering workforce in France.

These challenges highlight the urgent need for concerted efforts to encourage and support women in pursuing STEM studies and careers. Initiatives such as mentorship programs, inclusive policies, and transparent recruitment practices are essential in mitigating gender disparities and fostering a more diverse and equitable workforce in technology-related fields.

The stereotypes mentioned can lead to underestimating women's technical abilities and overestimating men's abilities. Media representations of engineers, computer programmers, scientists, and other STEM professionals often portray them as masculine, reinforcing the idea that technical skills are primarily male. Gender stereotypes associating men with technical skills and STEM fields are deeply ingrained in societal norms. These biases, along with institutional barriers such as prejudice, discrimination, and unequal access to educational and professional opportunities, significantly contribute to the underrepresentation of women in Low-Tech sectors.

The article, written by the Knowhow Editorial Team, examines the representation of women in STEM professions within the European Union. Currently, only 17% of individuals working in these fields are women. However, these figures vary significantly from one country to another. For instance, in Bulgaria, nearly 30% of STEM professionals are women; in Hungary, this number drops to just 14%. Despite an upward trend, women remain underrepresented in specific areas such as engineering and computer science. Statistics also reveal a persistent gender gap in STEM enrollment rates. For example, in 2019, only 16% of new engineering students were women; this figure was even lower in computer science, at just 10%. To bridge this gap, initiatives are needed to encourage more girls and women to pursue studies and careers in STEM fields[11].

The Observatory of Women[12] in France conducted a survey that highlighted the ongoing gender disparities in the field of engineering. In 2016, only 22% of engineers under 65 were women; for those under 30, the figure was even lower, with only 1 in 4 being female. Furthermore, 1 in 3 young engineers began their careers at the same company where they had completed their final internship. Despite a gradual increase in the number of female engineers, significant challenges still exist[13].

An article from Stanford Business School explores the lack of inclusivity for women in engineering by examining the enduring gender pay gap and systemic biases within STEM industries. It reveals that women in these fields typically earn 89 cents for every dollar earned by men in similar positions in the United States. The analysis explores various factors contributing to this disparity, including gender stereotypes influencing hiring practices and career advancement opportunities and discrepancies in negotiation tactics resulting in unequal compensation packages. Additionally, the article underscores the significant impact of career interruptions, such as caregiving responsibilities, on women's long-term earning potential within STEM fields. Despite progress towards gender equality, these findings highlight ongoing challenges hindering women's financial parity in STEM professions. The article advocates for inclusive policies, mentorship programs, and transparent salary structures to address these systemic issues and foster a more equitable workforce in STEM domains.

References and Further Reading:

[15.] Matuszak, J. (2023, March 9). Women in STEM in EU. KnowHow. https://knowhow.distrelec.com/stem/women-in-stem-in-eu/

[16.] Association Femmes Ingénieures. (n.d.). Accueil - Association Femmes Ingénieures. https://www.femmes-ingenieurs.org/

[17.] McGee, P. (2023, August 30). Women in STEM Statistics - STEM Women. Stem Women. https://www.stemwomen.com/women-in-stem-percentages-of-women-in-stem-statistics

Above: Low-tech with Refugees — Briançon's first workshop©2020_EKO!
All images from: https://association-eko.medium.com/low-tech-with-refugees-in-the-french-alps-7b9d841d4f2a

Left: Participants caught by Sylvain's explanations about the world of bees©2020_EKO!

Right: Lamine, developing a vocation for the craft of welding, and Guillaume, professional welder©2020_EKO!

3: Inclusivity and Low-Tech

Ableism

Furthermore, validism, or ableism, is a form of social discrimination against people with disabilities based on the belief in the superiority of non-disabled persons and the deviance or inferiority of disabled individuals. This discrimination manifests in barriers across various aspects of daily life, such as education, employment, healthcare, and public services. In Europe, approximately 100 million people live with a disability, often facing significant barriers that limit their full participation in society. To combat validism, it is crucial to challenge discriminatory norms and promote inclusive policies that recognise the specific needs of people with disabilities.

In the field of STEM, ableism is evident in inadequate recruitment and engagement of disabled individuals, as well as insufficient data and representation in advisory and leadership roles. To promote inclusion, it is necessary to adopt approaches like Universal Design for Learning (UDL)[18], which advocates for flexible and accessible learning environments for all students.

On the other hand, the Low-Tech movement, while offering ecological and economic benefits, can inadvertently perpetuate validism by not considering the specific needs of people with disabilities. For instance, Low-Tech solutions like cargo bicycles may not be accessible to people with mobility impairments, highlighting the importance of integrating accessibility principles into the design of such technologies from the outset.

Juliette Lesne, through her project with the Low-Tech Lab, sheds light on the specific challenges faced by people with disabilities in adopting Low-Tech solutions. She emphasises the importance of designing these technologies collaboratively and inclusively, considering users' diverse needs, to overcome the barriers of validism and create a more equitable technological environment for all.

In conclusion, addressing validism in technical and technological practices requires a systemic and inclusive approach that recognises the diversity of abilities and values the expertise of people with disabilities in co-designing innovative and accessible solutions.

Conclusion

We have thoroughly explored the potential of Low-Tech solutions in addressing societal challenges while promoting inclusivity, equity, and equality.

We began by defining inclusivity as integrating individuals or groups and ending social exclusion, emphasising the importance of fostering social justice and human rights. Through the lens of precarity, we have examined various forms of vulnerability, particularly in France, including digital poverty, economic instability, and energy precarity, highlighting the urgent need to address systemic inequalities.

Despite the potential of Low-Tech solutions to mitigate these challenges, we acknowledge the persistent gender disparities within STEM fields and Low-Tech sectors, pointing to institutional biases and barriers that hinder women's participation and representation.

However, inclusive practices also exist within Low-Tech initiatives, such as horizontal governance structures and partnerships that prioritise accessibility for individuals with disabilities. In the future, it is essential to continue efforts to overcome gender disparities and promote inclusivity in technology-related sectors.

References and Further Reading:

[18.] LibGuides UFV: Ableism: Universal Design of Learning. (n.d.). https://libguides.ufv.ca/ableism/universal_design_of_learning

Design for Sustainability

our socio-ecological challenges

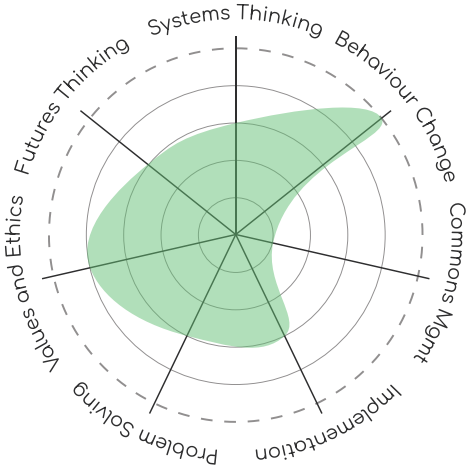
Tatiana Reyes & Luis Miguel López Santiago

6 lessons
3 Workshops

Above: Tara Winstead. A Child Looking at His Toys on the Table. January 2021. Pexels. https://www.pexels.com/photo/a-child-looking-at-his-toys-on-the-table-6692925/

Design for Sustanability

our socio-ecological challenges



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	Introduction to the principles of sustainability, tools for social and environmental assessment, historical and theoretical perspectives on technology, and practical strategies for applying low-tech solutions in collaborative design contexts	15
Workshop	Focussing on: practical skills in applying environmental and social sustainability assessment tools, understanding the impacts of climate change, exploring frameworks like Planetary Boundaries and Doughnut Economics, and preparing for collaborative low-tech design challenges.	15
Self-Directed	Sustainability practices and case study analysis. Preparation for a hackathon on low-tech	30

Module Objectives

This module provides the theoretical background for the discussion and analysis of sustainability issues focusing on the relationships between socio-technical and ecological systems.

The module focuses on the following main aspects:

1. The definition of sustainability and the most relevant social and environmental sustainability assessment methods/tools.
2. system thinking approach applied to current socio-ecological issues.
3. Reflection on the history and evolution of "Technology" and "Technique" and their role in developing low-tech(s).
4. the role of today's geo-political aspects (stakeholders, economic interests, institutional agendas...) affecting the development of sustainable practices.
5. ethical aspects and societal values in the context of sustainability.
6. Present the scales of implementation of the Low-Tech philosophy (from product to socio-political projects)

Students will examine the local and global (and glocal) interrelationships between the natural, social, economic, technological, political and cultural systems that allow and hinder the development of sustainable practices. This module places a heavy emphasis on peer discussion and practical work (workshops, case study analysis, etc.). Students would choose a topic of interest so they can develop a comprehensive understanding focused on the challenges of sustainability and their relationship with Low-Tech development.

Learning Outcomes

1. Using a multi-criteria and systemic perspective, the participant should be able to understand and explain the causes and consequences of the current socio-ecological crisis.
2. Understand the fundamentals of the Design for Sustainability (DfS) framework.
3. Using the DfS framework, the participants should be able to generate scenarios for Low-Tech development.
4. Identify and use the most relevant ethical and responsible engineering practices to develop sustainability strategies for the development of Low-Tech.
5. Identify the most relevant ethical discourses and practices according to chosen sustainability challenges.
6. Take a reflective look at the history and evolution of "technology" and "techniques".
7. Understand the Planetary boundaries and the Doughnut Economics approaches and reflect on their relationship with the development of low-tech.
8. Understand and use the most relevant social and environmental sustainability assessment methods/tools

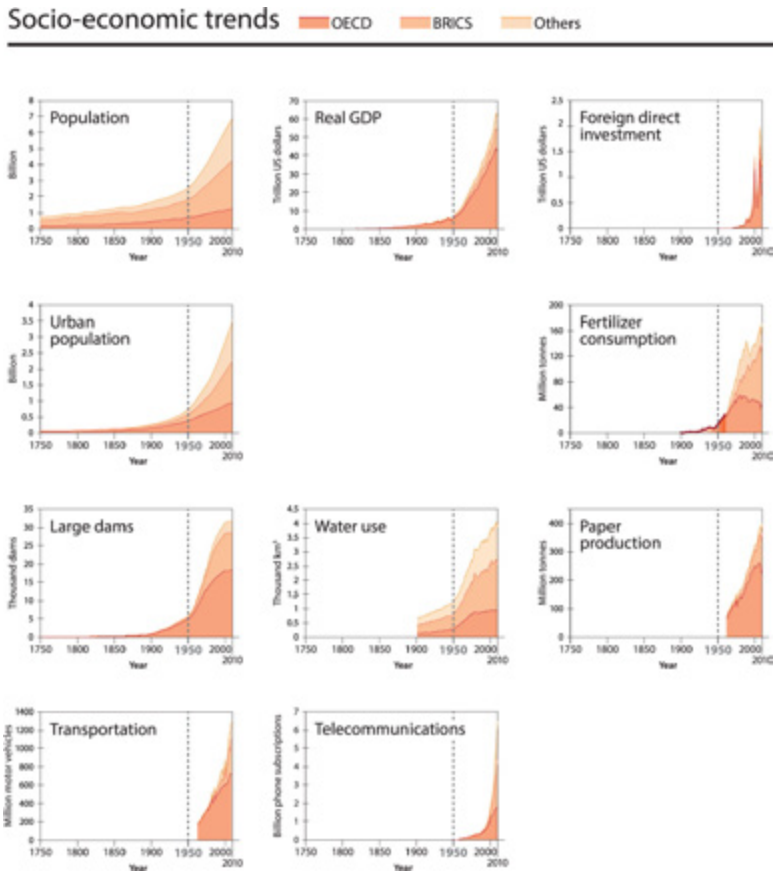


Figure 1: Trends from 1750 to 2010 in globally aggregated indicators for socio-economic development

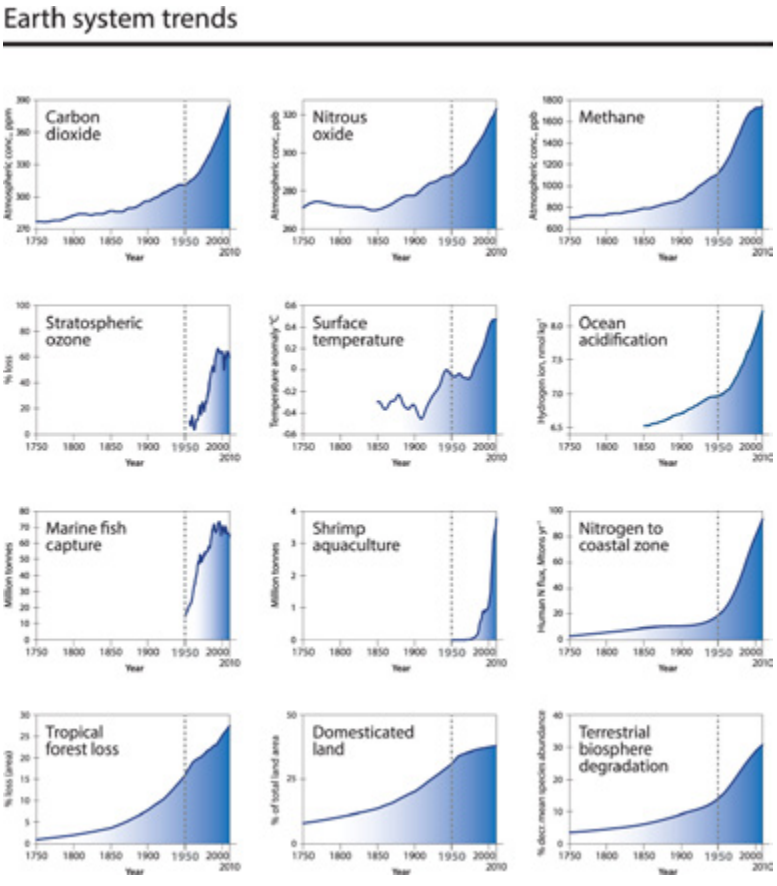


Figure 2: Trends from 1750 to 2010 in indicators for the structure and functioning of the Earth System.

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the anthropocene: The great acceleration Anthropocene Review, 2(1), 81–98. https://doi.org/10.1177/2053019614564785

1: Introduction to Sustainability

Sustainability: A wicked issue

Roots of Environmental Issues

Europe's current environmental and sustainability challenges stem from decades of global developments (European Environment Agency, 2023). Western society's progress is measured by indicators like GDP, which correlates with increased material and energy consumption and growing environmental issues (Parrique, 2019). Simon Kuznets, in his 1934 report to Congress, noted that "the welfare of a nation can . . . scarcely be inferred from a measure of national income (GDP)."

Only beyond the mid-20th century is there clear evidence for fundamental shifts in the state and functioning of the Earth System that are driven by human activities (Steffen et al., 2015). The term "Great Acceleration" denotes the rapid pace of human-induced changes during the latter half of the 20th century, an era unparalleled in human history. Numerous human endeavours experienced significant acceleration, reaching critical junctures and sharply increasing momentum as the century drew to a close (Figure 1). The Great Acceleration graphs have since become an iconic symbol of the Anthropocene, a term that signifies a new geological epoch driven by the impact of human activities on the Earth System, marking a significant shift in our relationship with the planet (Crutzen, 2002; Steffen et al., 2015).

The Great Acceleration trends provide a dynamic view of the emergent, planetary-scale coupling, via globalisation, between the socio-economic system and the biophysical Earth System (Steffen et al., 2015). We have reached a point where many biophysical indicators have clearly moved beyond the bounds of the Holocene (the only stable state of the Earth System that we know for sure can support contemporary society). The need for effective planetary stewardship is urgent as humanity consumes more resources than Earth's ecosystems can replenish sustainably. This reliance on Earth's natural capital and its productivity can temporarily enhance human well-being but is ultimately unsustainable. Without intervention, we risk pushing the Earth System onto an unsustainable trajectory towards irreversibly hostile conditions (Steffen et al., 2011, 2015).

How do we diminish material and energy flows to a sustainable state?

Our activities lead to a quadruple deadlock, all of them destroying biodiversity (Bihouix, 2021).

1. An increase in the use of nonrenewable resources and an overuse of renewable resources
2. Increasing levels of pollution (air, soil, water)
3. A saturation of sites
4. An increase in social inequalities

Definition of Sustainability

"Sustainability is about meeting the world's needs of today and tomorrow by creating systems that allow us to live well and within the limits of our planet." (European Environment Agency, 2023)

Fulfilling our needs today & tomorrow

Roots of our activities: What is a need? How answering it impacts the world?

At the core of sustainability lies a crucial understanding of what human needs are considered fundamental and how they are satisfied. This understanding is pivotal as it shapes the way we respond to these needs, distinguishing them from the conventional notion of 'desires' (which can be unlimited and never satisfied). According to Max-Neef, fundamental human needs should be understood as a system, not a hierarchy (as is often presented from Maslow's perspective).

Max-Neef's approach underscores that all fundamental human needs are not isolated entities but rather interrelated and interactive. He identifies nine fundamental needs: Subsistence, Protection, Affection, Understanding, Participation, Idleness, Creation, Identity and Freedom. These needs are distinct from the strategies used to satisfy them, which are largely influenced by contextual elements and conscious or unconscious factors such as culture, historical period, environment, and individual or collective preferences.

Max-Neef suggests a matrix that links fundamental needs and satisfaction modes without any hierarchy or order of satisfaction (cf. figure fundamental needs & satisfaction matrix).

Max-Neef further classified "satisfiers" (means of satisfying needs) as follows:

1. Violators: Claim to meet needs but make fulfilling them harder.
2. Pseudo Satisfiers: Claim to meet needs but have little to no real impact on fulfilling them.
3. Inhibiting Satisfiers: Over-fulfill a specific need, thereby significantly hindering the fulfilment of other needs.
4. Singular Satisfiers: Fulfill only one specific need.
5. Synergistic Satisfiers: Fulfill a specific need while helping fulfil other needs simultaneously.

Needs according to existential categories / Needs according to axiological categories	Being	Having	Doing	Interacting
Subsistance	1. Physical health, Mental health, Equilibrium, Sense of humour, Adaptability	3. Food, Shelter, Work	3. Feed, Procreate, Rest, Work	4. Living environment, Social setting
Protection	5. Care. Adaptability, Autonomy, Equilibrium, Solidarity	6. Insurance systems, Savings, Social security, Health systems, Rights, Family, Work	7. Cooperate, Prevent, Plan, Take care of, Cure, Help	8. Living space, Social environment. Dwelling
Affection	9. Self-esteem, Solidarity, Respect, Tolerance, Generosity, Receptiveness, Passion, Determination, Sensuality, Sense of Humour	10. Friendships, Family, Partnerships, Relationships with nature	11. Make love, Caress, Express emotions, Share, Take care of, Cultivate, Appreciate	12. Privacy, Intimacy, Home, Spaces of togetherness
Understanding	13. Critical consicence, receptiveness, curiosity, astonishment, discipline, intuition, rationality	14. Literature, teachers, method, educational policies, communication policies.	15. Investigate, study, experiment, educate, analyse, mediate.	16. Settings of formative interaction, schools, universities, academies, groups, communities, family.
Participation	17. Adaptability, receptiveness, solidarity, willingness, determination, dedication, respect, passion, sense of humour	18. Rights, responsibilities, duties, priviliges, work	19. Become affiliated, cooperate, propose, share, dissent, obey, interact, egree on, express opinions	20. Settings of participative interaction, parties, associations, churches, communities, neighbourhoods, family
Leisure	21. Curiosity, receptiveness, imagination, recklessness, sense of humour, tranquility, sensuality	22. Games, spectacles, clubs, parties, peace of mind	23. Day-dream, brood, dream, recall old times, give way to fantasies, remember, relax, have fun, play	24. Privacy, intimacy, spaces of closeness, free time, surroundings, landscapes.
Creation	25. Passion, determination, intuition, imagination, boldness, rationality, autonmy, inventiveness, curiosity	26. Abilities, skills, method, work	27. Work, invent, build, design, compose, interpret	28. Productive and feedback settings, workshops, cultural groups, audiences, spaces for expression, temporal freedom
Identity	29. Sense of belinging, consistency, differentiation, self-asteem, assertiveness	30. Symbols, language, religion, habits, customs, reference groups, sexuality, values, norms, historical memory, work.	32. Commit oneself, integrate oneself, confront, decide on, get to know onself, recognise onself, actualise oneself, grow	32. Social rythms, everyday settings, settings which one belongs to, maturation stages
Freedom	33. Autonomy, self-esteem, determination, passion, assertiveness, open-mindedness, boldness, rebelliousness, tolerance	34. Equal rights	35. Dissent, choose, be differen from, run risks, develop awareness, commit oneself, disobey	36. Temporal/spatial plasticity

Figure 3: Fundamental Needs and Satisfaction Matrix.
Max-Neef, M.A., Elizalde, A. and Hopenhayn, M. (1991) Human scale development: Conception, application and further reflections. Apex Press.

This classification of satisfiers allows us to reflect on how needs should be addressed, as they are not satisfied with a simple "yes" or "no" but can vary depending on how the needs are expressed.

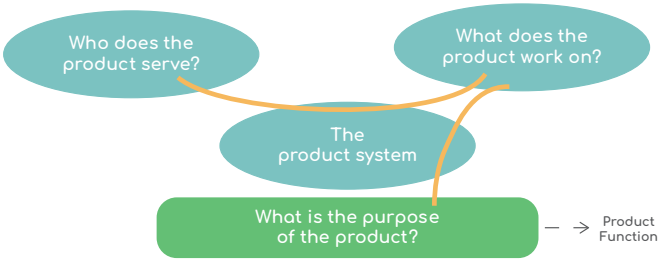


Figure 5:

Here needs have, by design, not the same value for people, following their culture and means of satisfaction. "The brand of a society resides both on the needs it privileges & on which answers are privileged in it".

- Which needs are privileged today?
- Which answers are privileged in our society?

The privileged needs are those that are available in the free market of products and services
→ a maximum of needs to make the economy function correctly

The answers often come as a product or services added to those which already exist.

Technological progress and Globalisation have added two things to the set of alternatives that address our needs:

1. New channels for answering our needs
2. Complexity and opacity in how it impacts the world

Favouring a free global market and technological innovation is the current choice of occidental society. This paradigm is called neoliberalism. Neoliberal policies and the market pre-make our choices of answers to our needs. Changing the prioritisation of our needs and their answers is a wicked issue because of the lack of power we have over our societal choices.

Interpretations of Sustainability

1st vision (neoclassical economy)

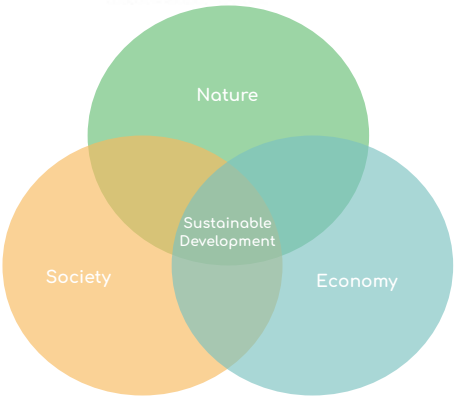


Figure 5: Weak sustainability

"To pass on to next generations the capacity to produce the goods and services they need". The stock of capital available to society must remain intact from one generation to the next, and its transformation should follow the rules (Vivien, 2009)

1. The revenue generated from exploiting non-renewable natural resources must be reinvested into technical capital through an investment fund or taxation system.
2. States should regulate the allocation of resources by the price system inherent in the competitive market to prevent suboptimal consumer choices.

This means that technical progress allows for substituting different forms of capital when natural resources are depleted, thanks to "backup techniques."

2nd vision (ecological economy)

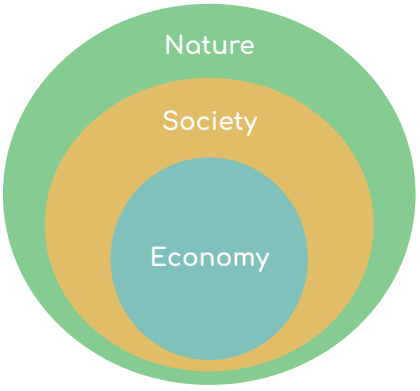


Figure 6: Strong sustainability

"To maintain, over time, a stock of critical natural capital that future generations cannot do without" (Vivien, 2009)

1. The rate at which renewable natural resources are exploited should be, at most, the rate at which they can regenerate to preserve their sustainability.
2. Waste emissions should not exceed the recycling and assimilation capacity of the environment where they are disposed of.
3. Non-renewable natural resources should be exploited at a rate equal to their substitution by renewable resources.

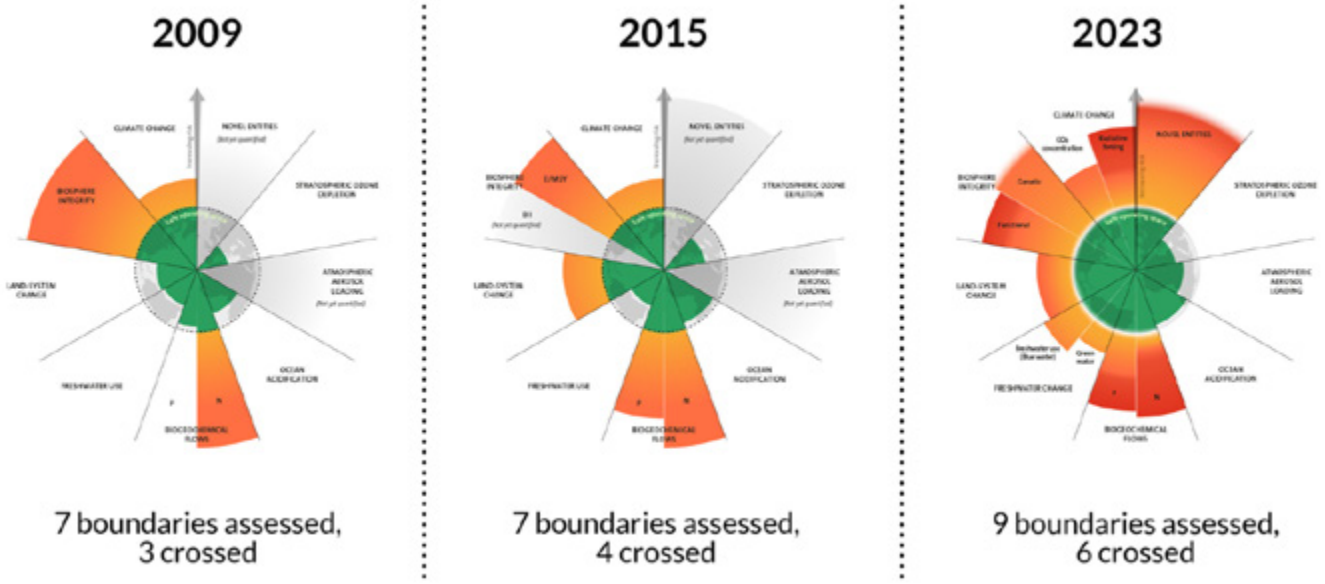


Figure 7: The evolution of the planetary boundaries framework. Licenced under CC BY-NC-ND 3.0 (Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009)

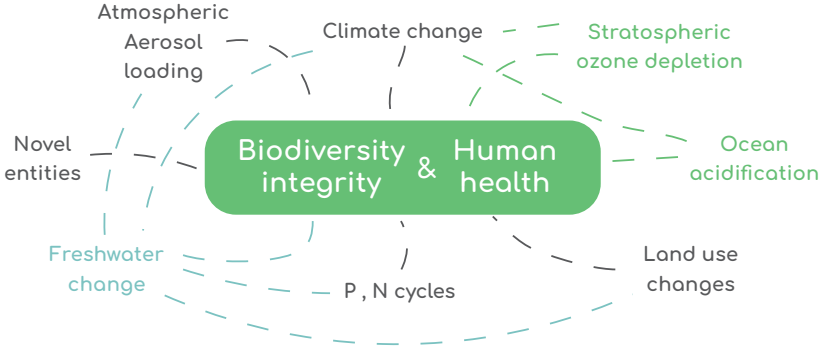


Figure 8: Recapitulation of Interactions between boundaries

2: Limits of our planet

What are Planetary boundaries?

In September 2023, a team of scientists quantified nine processes responsible for regulating the stability and resilience of the Earth system. These are known as planetary boundaries and suggest a set of nine limits within which humanity can continue to develop and thrive for many generations to come. These boundaries are:

1. Freshwater change
2. Stratospheric ozone depletion
3. Atmospheric aerosol loading
4. Ocean acidification
5. P and N biochemical flows
6. Novel entities
7. Land-system change
8. Biosphere integrity
9. Climate change.

According to the latest update, six planetary boundaries have been transgressed. Crossing these boundaries increases the risk of generating large-scale, abrupt, or irreversible environmental changes. While drastic changes may not happen overnight, these boundaries represent a critical threshold for growing risks to people and the ecosystems we are part of. This is described in Figure 7 on the opposite page

Boundaries refer to the interconnected processes that occur within the Earth's complex biophysical system. It is important to note that achieving sustainability requires more than just a global focus on climate change. To effectively achieve sustainability, it is crucial to comprehend the interplay of various boundaries, particularly those that involve climate change and biodiversity loss, see fiugre 8, opposite. This understanding is essential in both scientific research and practical applications. Can we live correctly, under certain circumstances, without some actual needs?

What are the human minimums for a safe and just life?

Doughnut Economics

Humanity faces a significant challenge in the 21st century: to meet every person's basic needs without overusing Earth's resources. This includes providing essential requirements like food, shelter, healthcare and political representation while ensuring that we do not harm the planet's life-supporting systems, such as a stable climate, fertile soils, and a protective ozone layer. To address this challenge, the Doughnut of social and planetary boundaries is a playful yet serious approach that guides human progress this century. (Raworth, 2012, 2017).

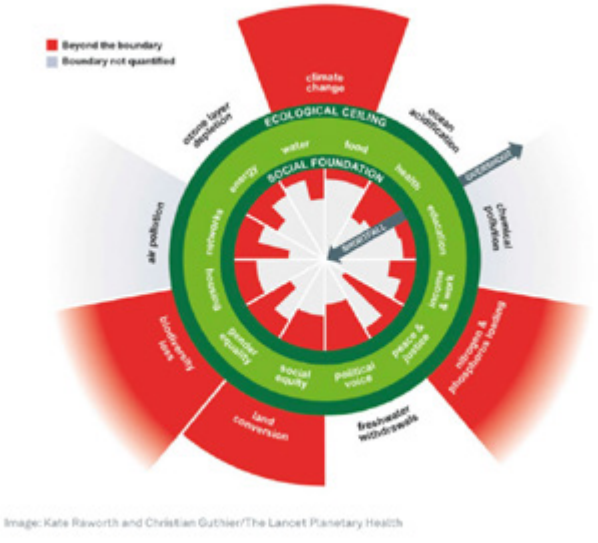
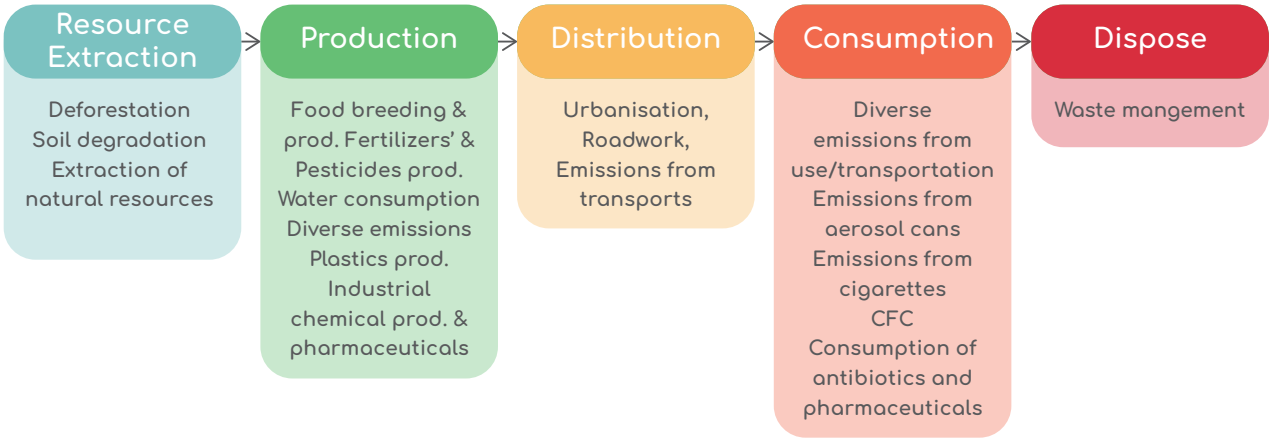


Image: Kate Raworth and Christian Guthier/The Lancet Planetary Health

Figure 9: Shortfalls and overshoot in the Doughnut (Raworth, 2017)



Above: Sang Tran. woman in white tank top and pink floral skirt sitting on chair. January 2021. Unsplash. https://unsplash.com/photos/woman-in-white-tank-top-and-pink-floral-skirt-sitting-on-chair-41Tc-C2aX0M

3: Design for sustainability (DFS)

What is Design for Sustainability?

Sustainability requires a process-based, multiscale and systemic approach, guided by vision rather than goals (fig 10)

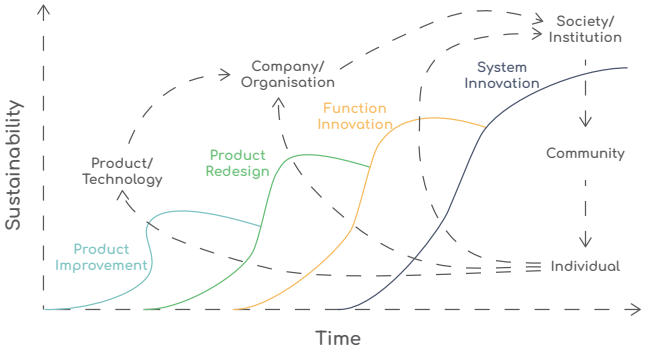


Figure 10: The contexts of change in relation to levels of design innovation for sustainability (Gaziulusoy & Brezet, 2015).)

The focus of DfS has also progressively expanded from single products to complex systems (fig 11). An increased attention to the 'people-centred' aspects of sustainability has allowed for this change. The first approaches have been focusing predominantly on the technical aspects of sustainability. The following have recognised the crucial importance of users' roles, the communities' resilience, and, more generally, the various actors and dynamics in socio-technical (Ceschin & Gaziulusoy, 2016).4

Sustainability-oriented innovations have evolved from a narrow technical and product-centric focus towards a focus on system-level changes (Ceschin & Gaziulusoy, 2019)Two important dimensions characterise this evolution:

- The technology/people dimension: the evolution from a technically focused and incremental view of innovation to innovations in which sustainability is seen as a socio-technical challenge where user practices and behaviour play a fundamental role.
- The insular/systemic dimension: the evolution from innovations that address an organisation's internal issues towards focusing on changing the more expansive socio-economic systems beyond the company's immediate stakeholders and boundaries.

Low-tech as one approach of the DFS

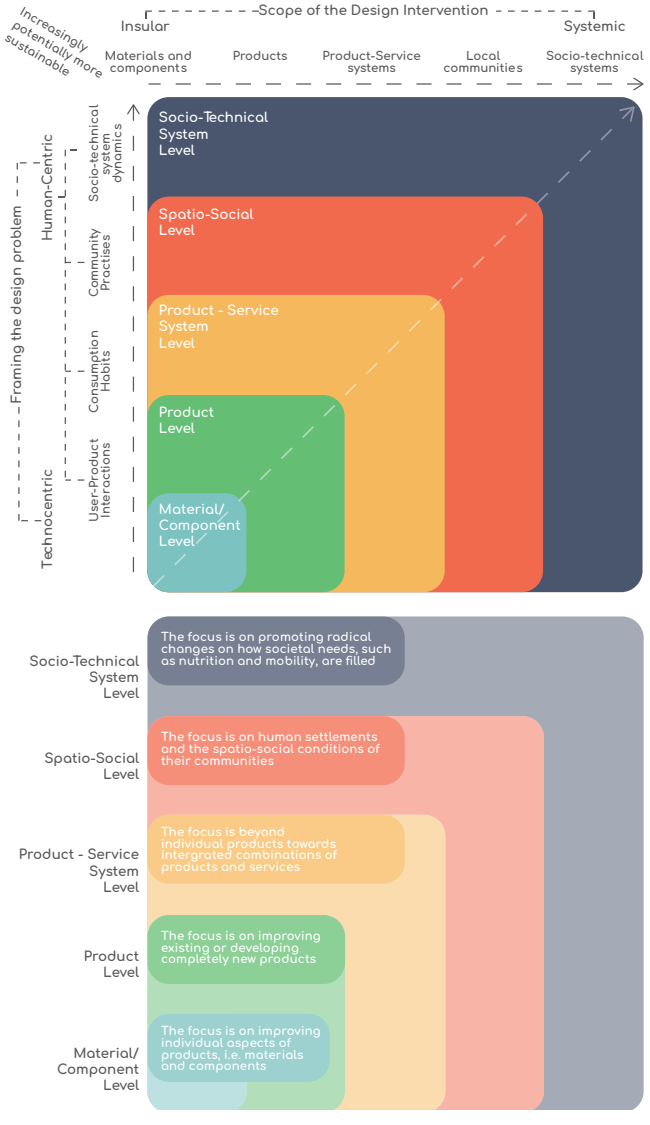


Figure 11: The DfS innovation framework (Ceschin & Gaziulusoy, 2019)

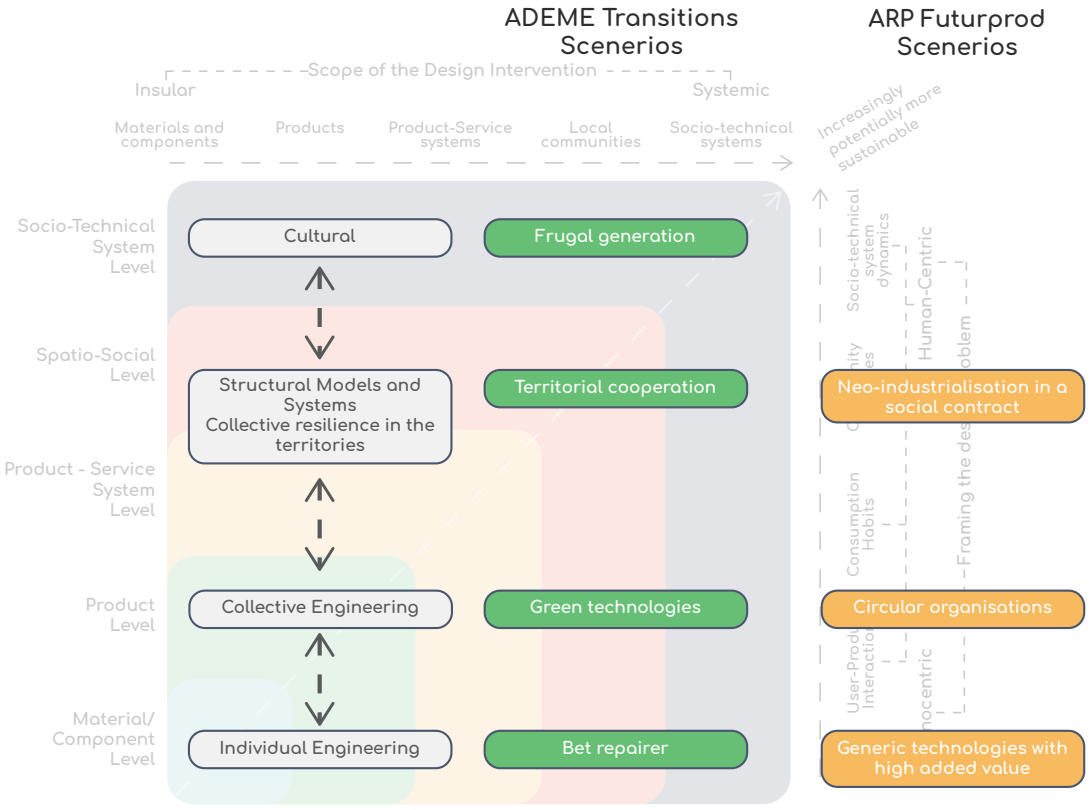


Figure 12: Scales of generalization of LT in the DfS framework at different levels.

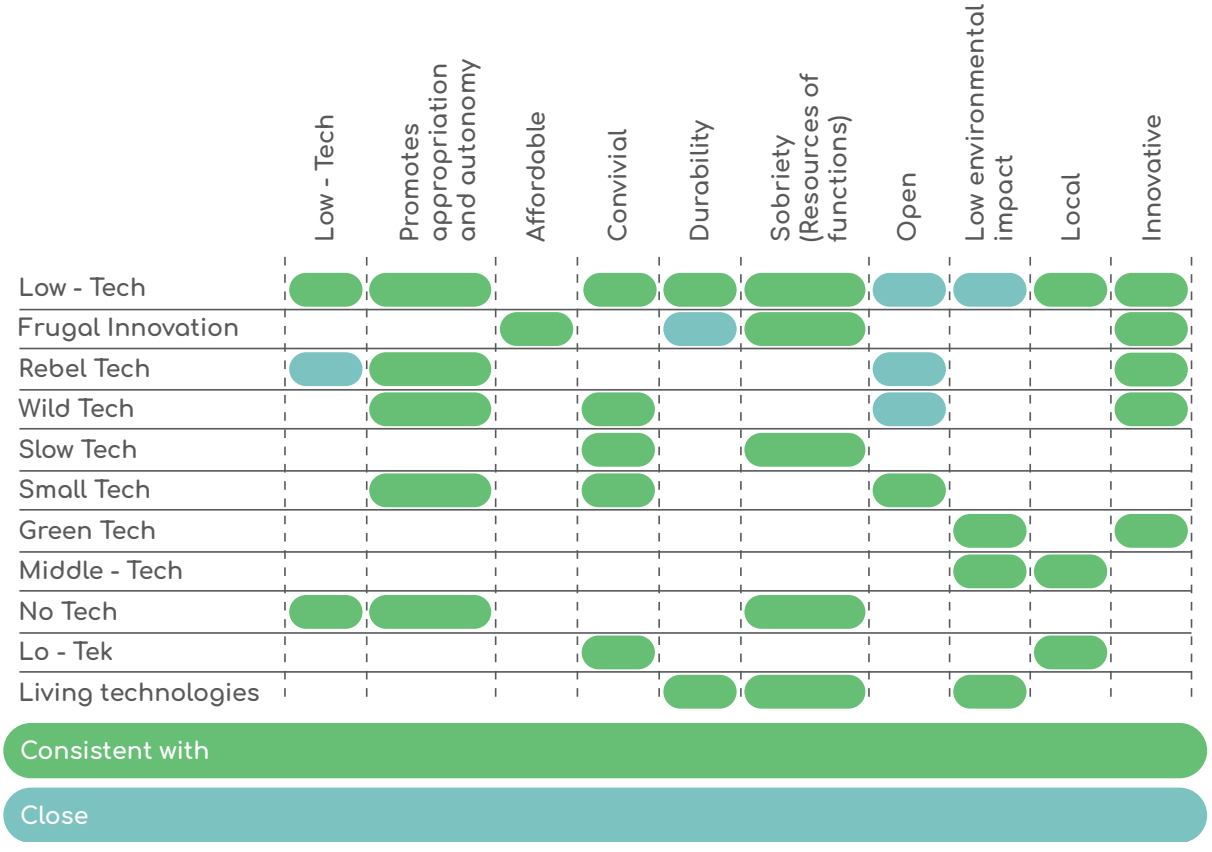


Figure 13: Articulation of low-tech with other concepts close to the philosophy of technology (ADEME 2022. État des lieux et perspectives des démarches « low-tech »)

4: Low-Tech as a D4S Approach

The Low-Tech philosophy

Low-Tech is a philosophy that aims to improve our relationship with the materiality of our needs, drawing on diverse technical movements and ecological principles. It maintains three clear objectives that solutions should be:

1. Useful → answering a need (does not create one). This relates to the content of what we produce.
2. Durable → it lasts in time (the need, its material or immaterial response). This relates to how we produce.
3. Accessible → People can choose, improve, and share them, and the improvements can be collectively chosen. This relates to how we organise, as a society, our activity of defining our needs and producing their answers, aka "Autonomy."

The low-tech approach has been proposed as a set of key application criteria and principles . These criteria and principles are found in the social, organisational, technological, collective, cultural transformation, and strong sustainability dimensions (Figure 13 & Figure 14)
The low-tech approach can be implemented and generalised at different levels of the DfS framework.

History of the low-tech concept

Academics and practitioners have defined the Low-Tech concept in various ways. (Low-tech lab, (Bihouix, 2021), (Tanguy et al., 2023), (Bonjean et al., 2022), ADEME 2022, (Keller & Bournigal, 2022), (Béranger, 2022), etc.). The approach is based in critical thinking related to the use of appropriate technologies.

Lewis Mumford (1964)
Democratic Technics

(being human centered, relatively weak, but resourceful and durable).
Small-scale production

André Gorz (1967, 1970)

Technologies that promote autonomy
Alternatives to capitalism that reduce environmental destructions and give people more autonomy

R. Buckminster Fuller (1967)

Operating Manual For Spaceship Earth
Doing more with less

Murray Bookchin (1965)
Towards a Liberatory Technology

To bring about a different world, we need liberating technology.

Allessandro Mendini (1976)
« dé-projet »

Radical minimalism, subtracting rather than accumulating, undoing rather than constructing.

E.F. Schumacher (1973)
Small Is Beautiful

Appropriate technology
Nature as capital to be preserved. Sustainable economy (reasoned exploitation). Integrate the well-being of workers and the preservation of humanity

Dieter Rams (1970)
Ten Principles for Good Design

Less, but better

Victor Papanek (1971)
Design for the Real World

Human-scale design
Do better with less

Ivan Illich (1973)
Tools for Conviviality

Give people tools that guarantee their right to work with independent efficiency

Philippe Bihouix (2014)
The Age of Low-Tech

Technology cannot solve all the problems related to planetary boundaries. The threat of increasing use of scarce resources

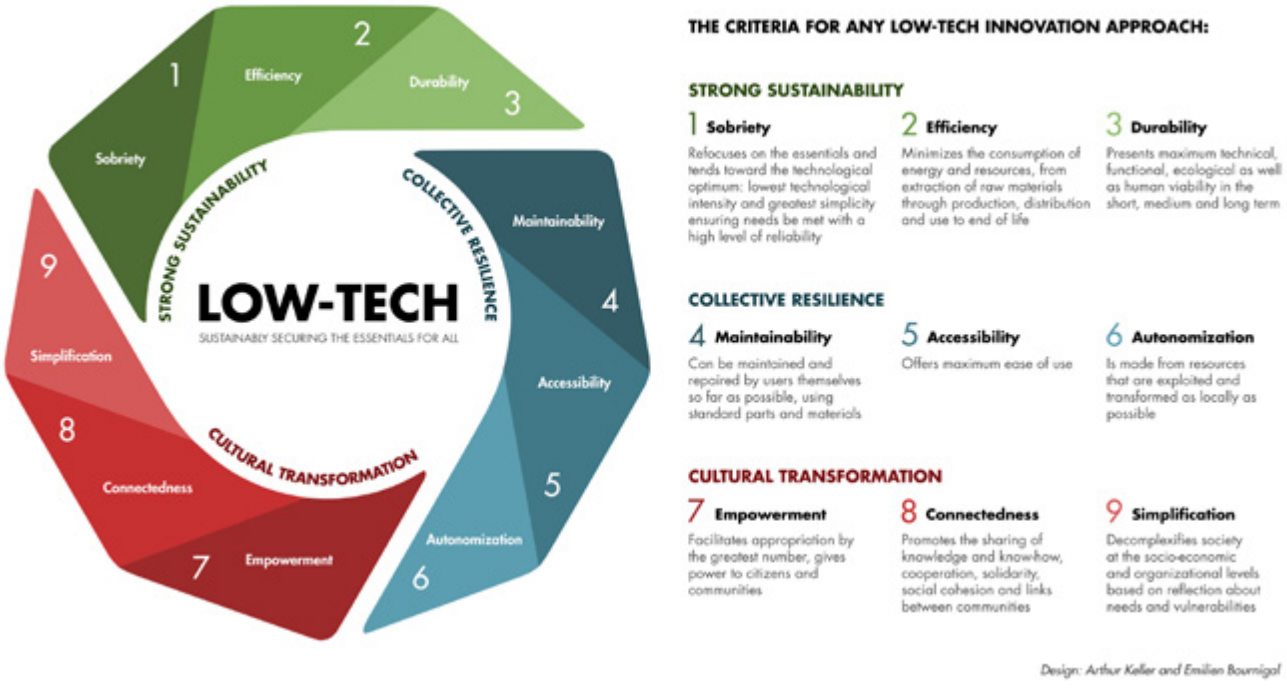


Figure 14: Infographic « Low-techs: Sustainably securing the essentials for all » gathering the criteria for any low-tech innovation approach (Arthur Keller and Emilien Bournigal)

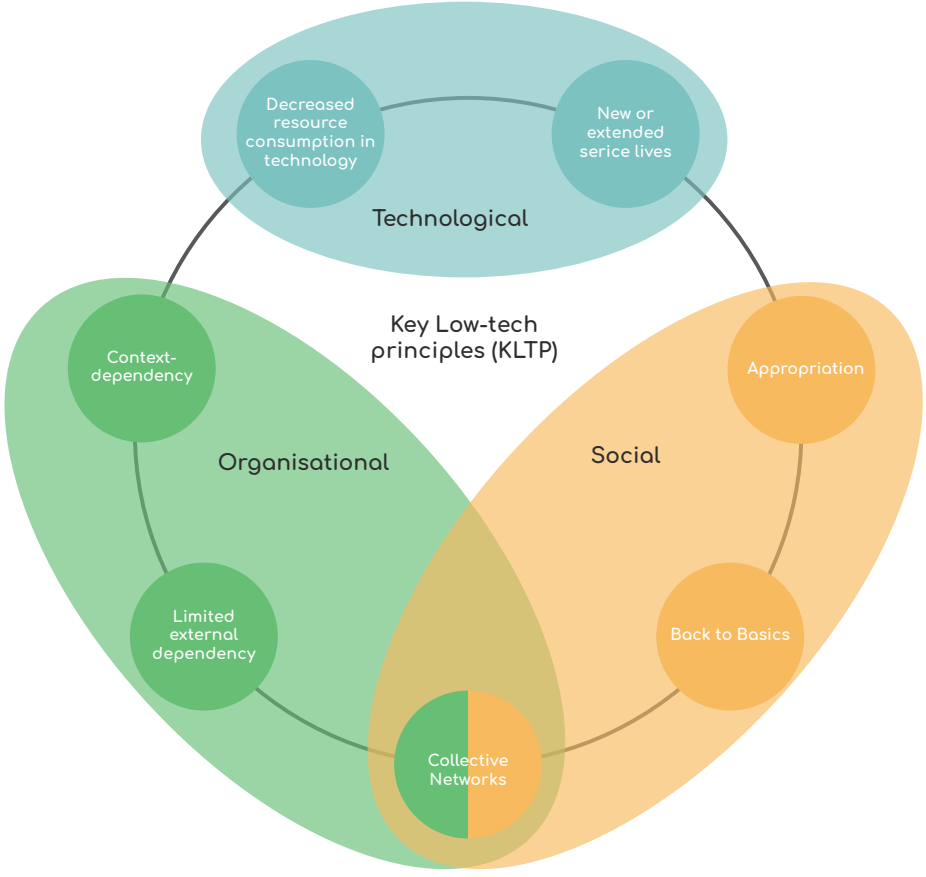


Figure 15: Seven key principles of low-tech systems (Tanguy et al., 2023)

4: Low-Tech as a D4S Approach

Low-Tech definition and other concepts:

For LT4SUSTAIN, Low-Tech is defined as: A value system to develop a paradigm focused on creating appropriate and accessible solutions that reflect, critique and generate new approaches to use less resources while responding to local needs (in a simple way) to create a more sustainable and inclusive reality.

Low-Tech is related to other concepts and approaches, which have common elements and some differences. (Fig 13)

Low-tech movements and actors

The Low-Tech movement has grown in recent years with more than 600 actors spread around the world who invent, apply, transmit, promote or support Low-Tech. (Fig 12)

Figure 16: Examples of structures of the Low-Tech Ecosystem (ADEME, 2022) (Bloquel et al., 2022)

Low-tech: Strengths, weaknesses, opportunities and threats

Strengths

- Synergy with issues of greater importance on a national scale: environmental impact, social justice, relocation.
- A dense network of actors to mobilize: artisans, environmental defense associations, and consumer groups.

Weaknesses

- Little offer.
- Lack of unifying cultural imagination on a large scale.
- Reluctance of institutional, financial, and regulatory actors.
- Poorly adapted regulations.
- Few large actors
- Political charge of the potentially repulsive concept: link with de-growth, the notion of renunciation, etc.
- Question of desirability and social acceptability.

Opportunities

Economical
- Relocation of economic activities in the territory (reuse, repair, manufacturing, local raw materials sectors).

Job creation.
- Innovation, research, and development.
- Reassert the value of artisanal and manual sectors.
- Gain in purchasing power (more durable tools over time, repairable).
- Reduction of international sourcing risks and reduction of external vulnerability.

Social
- Creation of social links.
- Increased community resilience.
- Acquisition and sharing of new knowledge, understandings, and skills.

Environmental
- Limitation of resource consumption (materials and energy)
- Reduce waste production.
- Reduce risk of rebound effect.

Threats

- For low-tech actors
- Misguided reappropriation of the concept by external actors
- Increase in demand greater than supply capacity.
- For consumers and citizens
- Loss of comfort for certain uses.
- Habit changes.
- For economic actors
- Increase in intermediate costs (intensification of the use of labor input rather than capital).
- Increased competition in certain markets.
- Reconfiguration of supply and logistics chains.
- Contraction of certain types of markets.
- Dependence on environmental conditions.

Above: Quentin Bassetti. Photo report about Atelier Paysan. April 2022. Socialter. https://www.socialter.fr/article/l-atelier-paysan-le-refus-de-rester-impuissants

Right: Agro Mauta. Bicimaquinas en mixuca. August 2010. Flickr. https://flic.kr/p/8vcpCq

5: Low-tech examples of D4S

In this chapter, we will discuss Design for Sustainability and showcase Low-Tech designs through different case studies. These examples will demonstrate how uncomplicated yet efficient solutions can contribute to environmental stewardship and efficient use of resources.

Moreover, we will discuss strategies to enhance the dissemination and accessibility of Low-Tech innovations, with the aim of reaching a broader audience and increasing their impact.

At this level, the low-tech approach can focus primarily on improving existing products or developing entirely new solutions. The relevance of low-tech at the product level involves questioning needs and evaluating the technical choices to be implemented, such as materials, performance level, availability, and cost. The strategies and criteria of the low-tech approach suggest designing with considerations for efficiency, repairability, robustness, resistance, recyclability, and quality. However, these solutions' environmental and social impacts must be prioritised to avoid potential rebound effects on both the product and user behaviour. Below are two Low-Tech examples at the product level.

Material, components and product level

Norwegian Cooker

Genesis and/or triggers of the idea

The Norwegian pot, created in 1870, is back and represent a solution to preserve the flavor and nutritional values of foods. Throughout history, efficient heat management and energy conservation have been crucial, particularly during times of scarcity or conflict. This flameless cooking method is increasingly popular, as it responds to the desire of some people to reduce consumption and save energy. In light of the ecological crisis, it is imperative to adopt eco-friendly cooking practices. Traditional cooking methods, are energy-intensive and contribute significantly to energy waste.

Features and improvements.

- 50% to 95% energy savings
- Extension of cooking without adding energy, simply by inserting the pot into an insulator.
- possibility of building one or buying one.
- Build with recycled elements

The taste and nutritional values of foods are perfectly preserved.

Product-Service-Systems, Spatio-social level

Bicimáquinas – pedal powered machines

Genesis and/or triggers of the idea

Started in 1997 with support from the Canadian organisation PEDAL. As a legacy to Guatemalan development, the Maya Pedal Association was established in 2001. They use parts from used bicycles to build Bicimáquinas. Maya Pedal supports small self-sustainable projects in order to preserve or improve the environment, health, productivity and economy of families in rural areas.

Multiple applications: water pumps, mixers, washing machines, saws or coffee pulpers.
Promotes staying in shape through physical activity, pedagogical tools.
Reduction of energy consumption and environmental impact.
Second-hand bicycle repair and sale services in the surrounding area.

Features and improvements.

- Tailor-made with a local team and numerous volunteers in their training center (association).
- Built with recycled bicycles or from new materials.
- Affordable, in the sense that they are inexpensive to build and allow users to avoid fuel costs
- Very simply reparation, without the help of a specialized technician.
- Bicycle parts available everywhere.

Usable in any location, without the need to be connected to an electrical network.

Product-Service-Systems Level

The low-tech approach can be implemented in developing systems that are organised to deliver value propositions to users, focusing on functions rather than isolated products. At this level, the Low-Tech philosophy promotes use and consumption based on access and sharing. These systems can be complex and composed of products and services, requiring collaboration and sharing networks (resources, knowledge, infrastructure, etc.). This approach seeks to reduce the environmental impacts of individual products and, in turn, strengthen collaboration networks by sharing common values such as ethics, respect for the environment, resilience, and empowerment.

Above: Charlotte Krebs. NeoLoco. 2022 from https://www.connexionfrance.com/

Neoloco, Solar Bakery

Genesis and/or triggers of the idea

Energy sobriety is above all, a social and cultural problem, much more than a technical issue. In his travels and professional experiences, he realizes that if the energy and material issue of the century is sobriety, economy and reduction of consumption, it is actually changing behaviors, references, models or energetic representations. Neoloco embodies the emergence of a new generation of conscious companies, combining solar craftsmanship, a cooperative model, and a commitment to sustainability.
Production of quality products, preserving quality of life, being profitable and moving towards increasing sobriety and autonomy.

- Rigorous, progressive and empirical reappropriation of knowledge and practices (scientific, technical, artisanal, organizational, etc.)
- An innovative business model around intermittent energy and long conservation products.
- Alliances with other local actors (manufacturing, seed producers).
- Access to Lytefire Hub with a dedicated builders forum where you can share and get tips with other users in English and in French.
- Lytefire team continues to explore various methods of disseminating this appropriable and emancipatory technology (quotation to order, bundle of plans for self-construction, daily rental, educational programs, etc.).
- Spreading widely ideas through training, events, educational days for schools, and info days.

Features and improvements.

- 100kg-210kg of fresh bread every day.
- Roasting 100 kg - 300 kg per month
- Uses only direct concentrated sun ray, no fuel costs
- Reaches up to 900°C, 240°C inside the oven after 1 hour
- Easy to clean: only water and soap to clean the mirrors
- When used and maintained properly, life expectation of 19 years

Cultural manifestations

Low-Tech Exhibition

The "Low-Tech" exhibition showcases a unique collection of innovative creations that have been reproduced using tools from the past. The exhibition includes a diverse range of interactive wooden installations and do-it-yourself inventions that highlight the importance of dialogue and constant evolution. By juxtaposing "low" and "high" technologies, the exhibition aims to emphasise the significance of innovation and the need for continuous progress.

Solar Sound System

The SolarSoundSystem network provides a service that enables renewable energy-powered events to offer a distinctive and engaging energy experience to their attendees. SolarSoundSystems operate on two renewable energy sources: the sun, in most cases, and generator bikes that are powered by the public through pedalling.

Left: NeoLocal. Solar roasting of Éveil Résistant.e. https://neoloco.fr/torrefaction/

5: Low-Tech examples of D4S

Spatio-social level

A broader and more systemic perspective on Low-Tech innovation underscores the diverse range of contributors. Key roles are played not only by individuals and communities but also by grassroots technicians, local institutions, and civil society organisations. These entities often collaborate to develop innovations, bringing their unique expertise and perspective to the table. The low-tech philosophy supports a territorial approach that examines local socioeconomic actors, assets, and resources to establish synergistic and resilient connections between production processes, natural processes, and the surrounding area. This can lead to new organisational methods and locally-based value chains, to drive macro-level changes (systemic, political, etc.).

L'Atelier Paysan

Genesis and/or triggers of the idea

The intensive and industrial agricultural model shows its environmental, economic, and health limits. In response to this, l'Atelier Paysan was created in 2009, fostering a collaborative approach to implement local, resilient, and ecological agriculture on small surfaces. The cooperative strives to promote the inventiveness of peasant knowledge and the recovery of work tools designed for the field. Based on the principle that farmers are themselves innovators, they have been collaboratively developing methods and practices to reclaim farming skills and achieve self-sufficiency using organic farming tools and machinery.

Philosophy of the project

Principle farmers are themselves innovators. Reclaim farming skills and achieve self-sufficiency in relation to the tools and machinery used in organic farming. From the design of appropriate machines to the sovereignty over food.

Actions and Solutions

- Collectively develop new technological solutions adapted to smallscale farming.
- Collaborative development of methods, tools and practices.
- Collectively develop new technological
- Solutions adapted to small-scale farming.
- Promote farm-based inventions.
- Make skills and ideas widely available through courses and educational materials.

Relevance at the Spatio-Social level.

L'Atelier Paysan supports small-scale farmers by providing tailored advice and guidance on agricultural tools that suit their unique needs. It accompanies them through the challenges of their farming journey, whether individually or collectively, and regardless of their production area. The project recognises the crucial role of social and technical farmer networks in enhancing production and facilitating knowledge-sharing. It focuses on collecting and promoting farmer-driven innovations as open-source resources, fostering a collaborative and innovative farming community.

L'Atelier Paysan also advocates for the critical and responsible use of farm machinery, encouraging sustainable practices. To this end, the project develops partnerships on technical and political issues with local, national, and international organisations, creating a robust support system for small-scale farmers.

Above: Photo (c) Cargonomia.

Above: Visites de fermes lors des Rencontres 2017. L'Atelier Paysan Flickr. June 6, 2017.

Cargonomia

Genesis and/or triggers of the idea

Cargonomia is the formalisation of pre-existing cooperation between three socially and environmentally conscious small enterprises operating in or near Budapest: Cyclonomia (DIY Bicycle Social Cooperative), Zsamboki Biokert, an organic vegetable farm and sustainable agriculture community education centre, and Kantaa, a self-organised bike messenger and delivery company.

Philosophy of the project

Cargonomia and its partner's activities aim to display how environmentally friendly and equity-based partnerships can create sustainable and meaningful community empowerment opportunities which offer concrete alternatives to standard profit-driven social and economic systems.

Actions and Solutions

- Increase access to locally produced products by promoting direct trade from local producers to consumer communities.
- Food products are distributed to customers/partners throughout the city using locally manufactured cargo bikes.
- The cargo bike system operates on a non-profit basis to make it available around the city for citizens and organisations. It is based on donation and self-organisation.

Relevance at the Spatio-Social level.

Cargonomia acts as a logistics centre dedicated to sustainable urban transport solutions, offering community members the opportunity to borrow, rent, or purchase locally manufactured cargo bikes.

It serves as an open space for community activities that promote sustainable transitions, conviviality, and the principles of Degrowth.

Cargonomia also hosts DIY and self-sufficiency workshops, discussions, and cultural events aimed at fostering collaboration between new and existing social and environmental outreach projects, creating synergies that support a more sustainable and resilient community.

Above: Eyoel Kahssay. A mother teaching her child how to plant a tree. August 2020. Unsplash. https://unsplash.com/photos/people-in-yellow-jacket-and-black-backpack-FyCjvyPG9Pg

Equipping practitioners with tools and methods to implement Low-Tech

Low-tech systems are crucial in the ecological transition, offering distinct economic (job creation, relocations, etc.), social, and environmental benefits. They are not just compatible with other sustainability concepts but also enhance them. Low-tech systems are not just useful and accessible, but they also foster local autonomy and sustainability, with low environmental impacts, resource consumption, and high durability (Bloquel et al., 2022).

The development of low-tech systems must consider their use or the intention behind their design. This development must promote sustainability through profound changes in behaviours, interactions, and the community environment. Therefore, a low-tech system must be implemented through a process that considers its context.

For this, a set of low-tech tools and methods (for support, assessment, and evaluation) is necessary to allow actors (academics, companies, associations, designers, citizens, etc.) to implement and disseminate low-tech systems.

Currently, numerous methods and tools are focused on sustainable design and innovation approaches (ecodesign, circular economy, PSS, etc.). However, some may not be compatible with the low-tech approach. In this sense, it is essential to consider some factors when choosing the tools and methods. Here are some considerations:

Support tools and methods (encouraging

There is a need for tools and methods adapted to each of the different actors in the low-tech ecosystem: collectives, communities, companies, and stakeholders. These tools must correspond to the level of maturity of the low-tech approach. Even in the makers movement, they are necessary to ensure a sustainable positive impact of the solutions developed.

The tools and methods could be developed and categorised in different levels (and used synergistically), for example:

- Strategic Level: to build the vision of the low-tech philosophy (indicators, roadmaps, deployment approaches, etc.). Characterisation of scenarios according to the context.
- Organisational Level: for adequate governance of networks that share the low-tech philosophy. Identification of social, organisational and territorial capabilities to be mobilised (cooperation, knowledge sharing, etc.).
- Operational Level: to be applied directly before and during the design process (technical choices, user integration, cocreation and codesign).capabilities to be mobilised

Assessment and evaluation tools

- Methods and metrics combining quantitative and qualitative approaches
- Evaluation of material and intangible value at different scales
- Assessment of risks and uncertainties

It is essential to consider that tools are needed at different levels, from micro (local) to macro (global). This will ensure that projects are situated within planetary boundaries or a regenerative approach.

New approaches, methods and tools for Low-Tech

The development of specific Low-Tech tools and methods is ongoing. An essential consideration is integrating prospective, holistic, and multifaceted thinking. These methods and tools could be inspired by new and good design practices that regularly emerge through local initiatives (grassroots).

Local low-tech initiatives and community-led movements have the potential to generate changes at macro levels. In this sense, low-tech tools and methods can be developed to create macro-level changes (socio-technical, spatio-social, political, etc.).

In this way, they would go beyond experimental stages and closer to the reality of the field. Below is a list of general considerations for developing new Low-Tech tools and methods.
New approaches and frameworks of reflection allow a radical questioning of modes of consumption and production.

- Tools must be territorialised relative to their environment/context (milieu). (La Fabrique Ecologique, 2019).
- Tools must be territorialised relative to their environment/context (milieu) (Institut Paris région, 2021).
- The tool must not create inequality but strengthen autonomy (Institut Paris région, 2021).
- It must generate efficiency without degrading autonomy (Martin & Colin, 2021).
- It must not raise either slave or master. Grimaud et al., 2017; Martin et al., 2022).
- It must broaden the scope of personal action (Bonjean et al., 2022)
- Convivial = by open definition (commons) (Bonjean et al., 2022)

References and Further Reading:

[1.] Bonjean, A., Fangeat, E., Forget, A., Fustec, A., Habe, C., Jaeger, R., Moiroud, L., Eloïse, M., & Clément, C. (2022). État des lieux et perspectives des démarches « low tech». https://librairie.ademe.fr/consommer-autrement/5421-demarches-low tech.html
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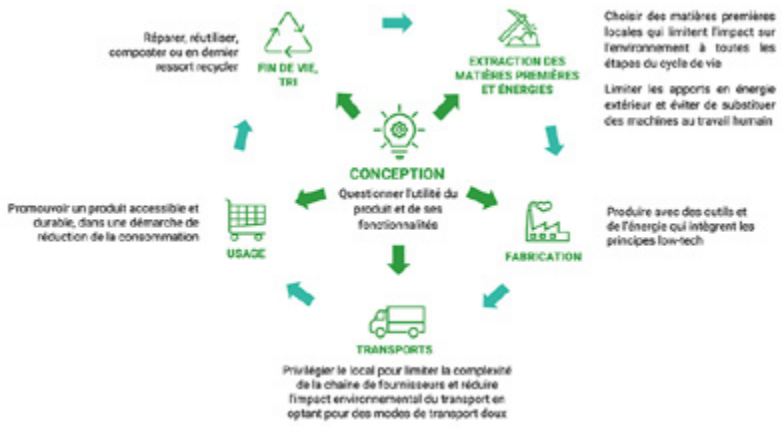
[6.] Martin, A., Gaultier, A., & Colin, C. (2022). Cartographie du concept low-tech :guider la conception vers des techniques soutenables. 56ème Congrès de La SELF, Vulnérabilités et Risques Émergents : Penser et Agir Ensemble Pour Transformer Durablement, 144–150. https://hal.science/hal-03598525

The table below presents some examples of tools and methods suitable for implementing the Low-Tech approach.

Product level

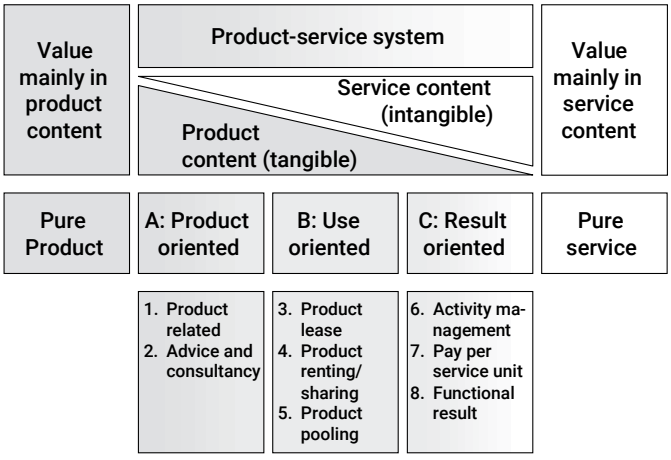


Article:
Bloquel, M., Bonjean, A.-C., Fangeat, E., Et Al. (2022).

Démarches « low-tech ».
https://librairie.ademe.fr/consommer-autrement/5421-demarches-low-tech.html

File and figure:
Démarches « low-tech » - Bloquel et al. – 2022
Figure 6. Pag. 40

Product/Service Level

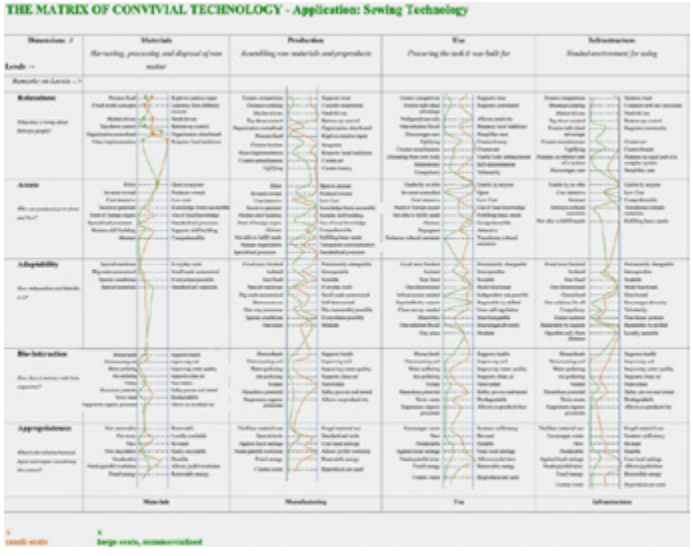


Article:
Tukker, A. (2004).

Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet. Business Strategy and the Environment, 13(4), 246–260.
https://doi.org/10.1002/bse.414

File and figure:
Eight types of product-service system Eight ways to sustainability Experiences from suspronet - Tukker - 2004
Figure 1. Pag. 248

User-Centred



Article:
Vetter, A. (2018).
The Matrix of Convivial Technology – Assessing technologies for degrowth. Journal of Cleaner Production, 197, 1778–1786.
https://doi.org/10.1016/j.jclepro.2017.02.195

File and figure:
The Matrix of Convivial Technology – Assessing technologies for degrowth - Vetter - 2018
Table 1. Pag. 1780

6: Methods for implementing the low-tech approach

Article:
Tukker, A. (2004).
Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet. Business Strategy and the Environment, 13(4), 246–260.
https://doi.org/10.1002/bse.414

File and figure:
The triple layered business model canvas A tool to design more sustainable business models - Joyce, Paquin - 2016
Anexe 1. Pag. 1483

Article:
Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014).
A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production, 65, 42–56.
https://doi.org/10.1016/j.jclepro.2013.11.039

File and figure:
A literature and practice review to develop sustainable business model archetypes - Bocken et al. - 2014
Fig. 3 Pag. 48

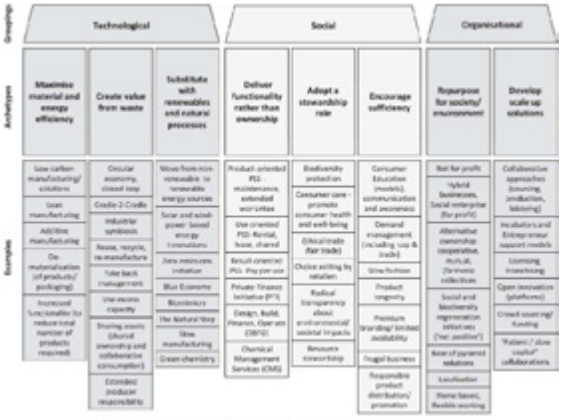


Figure 2: The sustainable business model archetypes (Bocken et al., 2014, p. 48)

Article:
ADEME. (n.d.).
Etude exploratoire : Déployer les low-tech dans les organisations d'Ile-de-France.
https://goodwill-management.com/wp-content/uploads/2021/09/Livre-blanc-LT_210830LD.pdf

File and figure:
Etude exploratoire Déployer les low-tech dans les organisations d'Ile-de-France - ADEME - Unknown
Figure (cover of the file)

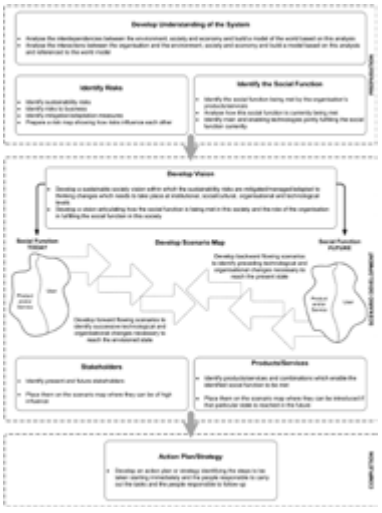
Above: Alizée Perrin and Yohann Vandendriessche. Materia exhibition, the essence of artistic crafts, presentation of the workshop. ND. Chemins de Faire. https://cheminsdefaire.fr/
https://www.socialter.fr/article/l-atelier-paysan-le-refus-de-rester-impuissants

6: Methods for implementing the Low-Tech Approach

Systemic approach

Article:
Gaziulusoy, A. I., Boyle, C., & McDowall, R. (2013). System innovation for sustainability: A systemic double-flow scenario method for companies. Journal of Cleaner Production, 45, 104–116. https://doi.org/10.1016/j.jclepro.2012.05.013

File and figure:
System innovation for sustainability A systemic double-flow scenario method for companies - Gaziulusoy, Boyle, McDowall - 2013(2)
Fig. 3 Pag. 108



Spatio-Social approach

Article:
Institut Paris région. (2021). La Ville Low-Tech. ADEME. https://librairie.ademe.fr/

Figure:
(cover of the file, first page)

File Link:
https://www.institutparisregion.fr/fileadmin/NewEtudes/000pack2/Etude_2734/urbalotek-011641.pdf

In Summary

Low-Tech aims to:

- Question our real needs and develop solutions that are as low-technological as possible.
- Minimise resources required for production and use.
- Don't inflict hidden costs on the community.
- Question models (systemic approach).
- Low-Tech is less technology (materiality) and more technology (know-how and good manners savoir-vivre).
- Reinsert the techniques into their environment (context milieu).

References

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Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production, 65, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

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Joyce, A., & Paquin, R. L. (2016). The triple layered business model canvas: A tool to design more sustainable business models. Journal of Cleaner Production, 135, 1474–1486. https://doi.org/10.1016/j.jclepro.2016.06.067

Tukker, A. (2004). Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet. Business Strategy and the Environment, 13(4), 246–260. https://doi.org/10.1002/bse.414

Vetter, A. (2018). The Matrix of Convivial Technology – Assessing technologies for degrowth. Journal of Cleaner Production, 197, 1778–1786. https://doi.org/10.1016/j.jclepro.2017.02.195

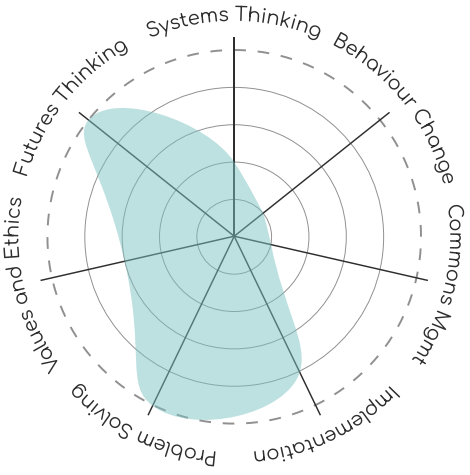
The Art of Simplicity

John Walsh & Paul Hendrick

7 lessons
3 Self-directed Student Assignments

Above: Lampe Improvisée, Improvised Lamp by Joschua Brunn (www.joschuabrunn.com), an example of Resourceful Design. See page 77

The Art of Simplicity



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	Introduction to the principles of sustainability, tools for social and environmental assessment, historical and theoretical perspectives on technology, and practical strategies for applying low-tech solutions in collaborative design contexts	15
Workshop	Focussing on: practical skills in applying environmental and social sustainability assessment tools, understanding the impacts of consumption and preparing for collaborative low-tech design challenges.	15
Self-Directed	Sustainability practices and case study analysis. Preparation for a hackathon on low-tech	30

Module Objectives

This module provides learners with a broad understanding of the concept of Low-tech and its application in the context of sustainability. It aims to equip students with the knowledge and understanding required in order to assess low-tech solutions and evaluate their appropriateness in a given context. The module further aims to develop the learner's appreciation of low-tech solutions from an aesthetic and philosophical context.

The module content consists of teaching material and resources that can be used by educators in a blended format as described above and can be modified to suit the needs of the particular student group. In particular, it suggests class-based activities that are designed to provoke thought, discourse and promote a low-tech mindset within the student cohort.

Learning Outcomes

1. Understand the value that Low-tech solutions can offer to ecological problems
2. Understand the value of Low-tech solutions from an aesthetic and usability perspective
3. Understand the spectrum of what can be considered as "Low-tech"
4. Critically evaluate the appropriateness of Low-tech solutions to a particular problem
5. Engage in critical discourse around the topic of Low-tech
6. Use the knowledge acquired to conceptualise low-tech solutions to a given problem

1: What do we mean by low-tech?

We typically understand the meaning of low-tech as the opposite of high tech, but in the context of this course and thinking about creating a more sustainable future, what does low-tech mean?

In many respects as a society, we have come to place increased value on high-tech, where low-tech is often looked on as inferior, less sophisticated, or the way things were done in the past.

Some of this may be true. Low-tech is often the way things were done in the past. Low-tech may in some instances be inferior, more difficult or more time consuming. Low-tech is often less spohisticated/ complex or less refined. But low-tech solutions often offer advantages over high-tech ones.

For the purpose of this course, rather than simply considering low-tech to the the opposite of high-tech, we will take a more wholistic view of the value of technological solutions and their appropriate use.

While there is no single official or agreed definition of low-tech, the primary aim of low-tech sustainability could be considered as the reduction in complexity of products/ services/ solutions in order minimise the use of valuable materials or resources in both their production and use.

Low-tech solutions typically:

> Are accessible to the widest possible amount of people
> Are highly useful or necessary
> Use minimum possible non-renewable energy in production
> Use minimum possible non-renewable energy in use
> Use minimum possible materials in production and use
> Use locally and sustainably sourced materials
> Are durable and simple to repair and maintain if needed
> Produce minimal harmful emissions in production and use
> Are simple to recycle or dispose of sustainably at end of life

Appropriate Technology / Simplest Means Practicable

Often when we think of low-tech we think of things like solar ovens. Solar ovens use the energy from the sun alone to heat and cook food by focusing sunlight on the food to be cooked. They can be a great low-tech solution– they use minimal energy in production and use, they are relatively simple and accessible to make and they don't produce any harmful emissions while being used for example. But while solar ovens area a great solution to certain situations such as camping or perhaps in some developing communities, they might not be practical for others like for day-to-day living in developed countries.

So, when thinking of low-tech, we also might want to think about how appropriate a low-tech solution is to a given problem. It can be useful to think of low-tech in terms of the Simplest Means Practicable to solve a problem or complete a task. We could say the simplest means possible, but possible solutions may not always be practical. For example if we take travelling a distance of 10 kms per day to work or university, while walking may be the lowest tech solution, it might not be practical. Driving by contrast is a high-tech solution. An appropriate solution might be going by bicycle, or even by E-Bike in some situations.

Activity

Discussion/ post-it-notes
Students will use post-it-notes to capture their thoughts on low-tech.

What do you think of when you think of low-tech? What do you think of when you think of high tech? Think quick and go with your gut instinct- there are no right or wrong answers.

Students will then present and discuss their thoughts with their peers

Above: Running Blades, an example of simple, elegant design that relies on material properties and geometry to replace or improve upon human running motion for amputees, without the need for complex mechanical components. See page 85

2: Principles of low-tech

There are 3 fundamental principles that we should think about when considering if a solution could be defined as low-tech. These are Strong Sustainability, Collective Resilience and Collective Cultural Transformation

Strong Sustainability

Sobriety
Refocuses on the essentials and tends towards the technological optimum: lowest technological intensity and greatest simplicity ensuring needs be met with a high level of reliability.

Efficiency
Minimises the consumption of energy and resources from extraction or raw materials through distribution and use to end of life.

Durability
Presents maximum technical, functional, ecological as well as human viability in the short, medium and long term.

Collective Cultural Transformation

Empowerment
Facilitates appropriation by the greatest number, gives power to citizens and communities.

Connectedness
Promotes the sharing of knowledge and knowhow, cooperation, solidarity, social cohesion, and links between communities.

Simplification
Decomplexifies society at the socio-economic levels based on reflection about needs and vulnerabilities.

Collective Resilience

Maintainability
Can be maintained and repaired by users themselves so far as possible, using standard parts and materials.

Accessibility
Offers maximum ease of use.

Autonomisation
Is made from local resources that are exploited and transformed as locally as possible.

Above: Finding beauty in simplicity: Vases (top) and Fruit Bowl (bottom), designed by Enzo Mari

3: Finding beauty in simplicity

We have all heard the phrase "Less is More", but what does that mean? How can we find beauty in simplicity and can Less mean More Sustainable?

The phrase "less is more" is commonly associated with the Modernist movements in art, architecture, and design. Although the origin of the phrase is unclear it is often used in reference to the architect Ludwig Mies van der Rohe, a leading figure in Modernist design and a director of pioneering Bauhaus school.

Less is more is also associated with the Minimalism movement which emerged in the middle of the 20th century and promotes simplicity over ornamentation. In Architecture for example, minimalism favours the use of clean lines, limited decoration and open spaces.

Another well-known phrase, "form follows function", is also closely associated with both minimalism and modernism. It espouses a form of rationality where the materials and structure of a building or product are exposed rather than covered up.

The principles of less is more, minimalism and form following function promote "honesty" in materiality and finding beauty in simplicity of form and structure by stripping objects or spaces of unnecessary embellishments. While these movements and ideas are not directly connected to the low tech movement, the concept of reducing a product or space to only it's essential components could be considered to be useful in a low tech context. We can also look to these ideas to understand the concept of finding beauty in simplicity.

In the philosophy of aesthetics, simplicity is often considered to have an emotional appeal; for example, by simplifying products to only what is necessary we may offer a counterbalance to the complexity of the world in which we live. For some people, this simple rationalism can provide a sense of peace or order, prompting feelings such as tranquillity, calm, focus and mindfulness.

The principles of less is more and form following function can also have benefits beyond aesthetics. The reduction of a product to its core functional requirements can also prioritise usability- by removing excess or unnecessary functionality and leaving only what truly serves an essential purpose can make a product easier to understand, more intuitive and therefore, useful.

How can less be more sustainable?

Unfortunately less is not always more sustainable; there are many products today that adhere to the visual principles of minimalism or less is more, but a simple external appearance often masks highly complex and high tech internal components and systems. However if we take some of these concepts we can develop guiding principles that support more sustainable solutions.

Prioritise Utility: By designing products that are less complex we can support easier repair and therefore a longer life with less need for replacement. This can also support more easy disassembly and recycling at the end of the product's useful life.

Elimination of Excess: By rationalising and reducing a product to its essential functions and components we can reduce the amount of energy and materials required to produce it. We can also create products that are easer to use and understand.

Timelessness: By focusing on simplicity of aesthetics or form following function as opposed to responding to a trend or fad, we can find beauty in simplicity and create products and transcend fashion and are valued by users for a lifetime.

Activity

Homework: Finding beauty in simplicity

Over the course of a week, students are encouraged to find examples of beauty in simplicity in every day life. They should focus on low-tech human made solutions/ artefacts. They will photograph and present their findings to the class

Above: Braun TP 1 transistor radio with phonograph designed by Dieter Rams
Image: PeterAjtony, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

4: Dieter Rams: Less, but Better

While there are many designers whose work is synonymous with principles such as less is more, one of the most influential of these is the German Industrial Designer Dieter Rams.

Rams was born in 1932 in Wiesbaden, Germany. He initially undertook a carpentry apprenticeship before going on to study Architecture and Interior Decoration at the Wiesbaden School of Art, graduating in 1953.

In 1955 Rams joined German consumer products company, Braun, where over the following 40 years he is credited with designing over 100 products, many of which are featured in the collections of Art & Design Museums worldwide. Rams was heavily influenced by functionalism in architecture and his work epitomises simplicity, functionality, clarity and unobtrusiveness. According to Rams, his designs "do not boast about themselves, take centre stage or restrict but withdraw into the background. Their reduction and unobtrusiveness generate space." Rams philosophy of simplicity extends to his personal life – he has lived in the same, relatively modest and unchanged bungalow since 1971.

Braun's products were generally in the category of consumer electric/ electronics and include devices such as radios, record players, coffee machines, food mixers and calculators. In most respects Ram's designs would at the time have been described as high tech, however underpinning his work is a philosophy of sustainable design that resonates today and has some relevance in the context of low tech thinking. These principles promote less but better products, products that are long lasting, products that are environmentally friendly. In essence, Rams products were driven by necessity, informed by usability, built to be durable and were visually designed not to suit a current a trend but to last a lifetime.

In the late 1970s, Rams came up with his 10 Principles of Good Design. These principles have become iconic and are still referenced by designers and taught in design schools.

10 Principles of Good Design

1. Good design is innovative.
2. Good design makes a product useful.
3. Good design is aesthetic.
4. Good design makes a product understandable.
5. Good design is unobtrusive.
6. Good design is honest.
7. Good design is long-lasting.
8. Good design is thorough down to the last detail.
9. Good design is environmentally friendly.
10. Good design is as little design as possible.

Activity

Talking points

Discuss, which of Rams' principles do you think could apply to low-tech? For example, if we make products more understandable, we may be able to make them easier to repair. What do you think about Ram's 10 principles - do you think they are still relevant today? Do you think they are relevant in the context of low tech?

Above: Toio Floor Lamp designed by Achille and Pier Giacomo Castiglioni

5: The Art of Resourcefulness

How can we find functional and aesthetic solutions from the resources around us?

In 1962 Italian Designers Achille and Pier Giacomo Castiglioni designed Toio, a floor lamp constructed from a selection of ready-made objects and components that were available to them. Toio's light source consisted of a standard uncovered halogen bulb, typically used as car headlights at the time. A fishing rod provided both adjustable height and a route for the power cable, while the transformer doubled up as a ballast to keep the lamp stable. The lamp also consisted of a simple frame made from off-the-shelf standard steel sections. Although Toio ultimately went into production, it can be viewed as an example of resourceful design – creating a useful and desirable object from ready-made or found resources. The lamp is also an example of functional design which exposes its engineering/ functional components rather than hiding or covering them, making repair, if required, straightforward.

Typically, one of the key requirements for a solution to be considered as low-tech is for it to be made from locally available resources. This resourcefulness requires multiple skills such as creativity, problem-solving and the ability to be able to adapt and adjust to different circumstances.

Being resourceful also requires the embracing of constraints– rather than looking at constraints as limitations to our ability to solve a problem, resourceful designers see them as opportunities to find creative or innovative solutions.

Another useful tool for resourcefulness is analogical thinking. Analogical thinking can be defined as the ability to use information or solutions from one domain to help solve a problem in another. In the case of Toio for example the Castiglioni's recognised that the features of a fishing pole could provide solutions to some of the functional requirements of a floor lamp.

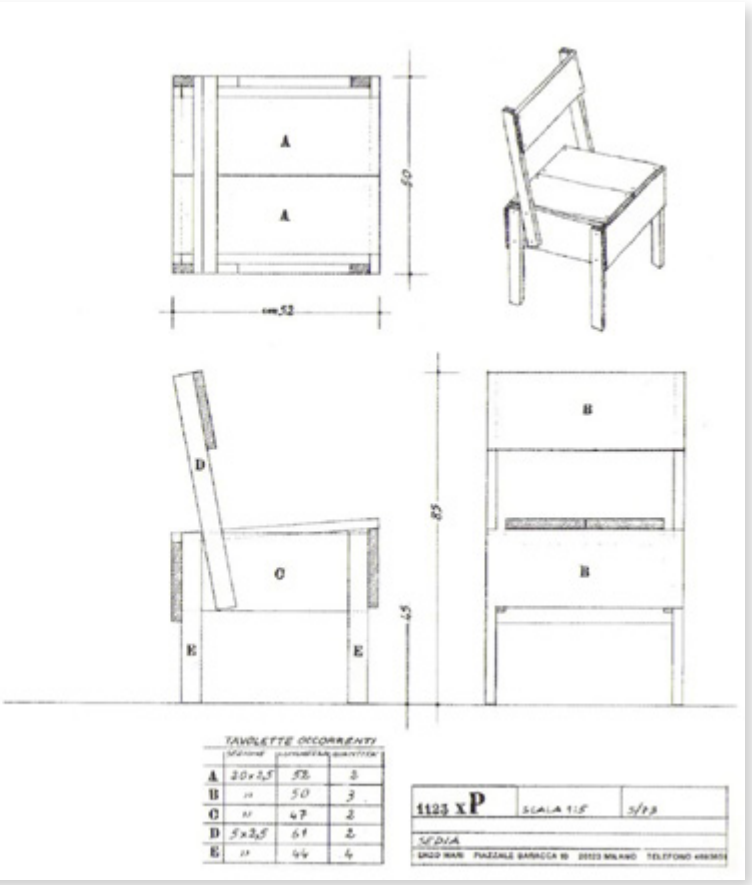
The ability to be resourceful, even when resources are plentiful, has multiple benefits. While there is an obvious benefit to the environment there can also be a commercial benefit such as a reduction in material or production costs. Resourcefulness also supports resilience in communities by providing the ability to adapt to unexpected challenges.

In 2006, Furniture and Product Designer Chris Jackson challenged 10 London based designers to design products that would provoke discussion about sustainability. With a budget of £10 and working within a 10km radius of their studios, the 10 designers had to scavenge materials and utilise resources available to them to design and make a product in a batch of 10. The project, called Ten, produced designs that were thought-provoking, humorous, functional and desirable and were examples of how we can find beauty and function in simple and often discarded resources.

Activity

10 x 10 Project

In this project, students are required to follow the brief set our as part of the Ten project above. They are challenged with designing a low-tech product and making a batch of 10 using only resources that are available to them locally, and with a total budget of €10. The products should be useful, functional and beautiful/ desireable.



Top, Bottom Left: Autoprogettazione chair design by Enzo Mari
Bottom Right: Tiptoe table legs

6: Democratic Design & DIY

Can design be a political activity? Can design be a means to transform society and promote resilience?

Enzo Mari (1932–2020) was an Italian modernist designer renowned for his commitment to the concepts of democratic and socially responsible design. In his design work and writing, Mari challenged consumer culture and his philosophy espoused functional, accessible and sustainable design.

Mari was a proponent of a type of self-reliance, where users take a participatory approach in the design and creation of everyday necessities. In 1974, Mari launched his "Autoprogettazione" project. Autoprogettazione, which can be translated as "self-design", provided users with easy to make designs and instructions to construct their own furniture using basic and readily available materials like such as standard timber sections and nails.

Mari's believed that by involving users directly in the creation process they would gain a deeper understanding of design and production. He felt that this would empower and liberate people, making them more resilient and less dependent on consumerism, fashion and mass-produced products.

Politically, Mari was deeply influenced by Marxist theory; he viewed design as a political activity capable of driving social change. He stated, "The first problem facing a designer is to define his own model of an ideal world, and not to create an aesthetic." He advocated for the creation of durable, low-cost, and multifunctional objects that could serve society equitably, stationg "I regard the word egalité as my faith... I want to believe in the possibility of equality through design".

Throughout his career, Mari maintained a critical stance toward the commercialisation of design. He sought to produce objects that were not only aesthetically pleasing but also ethically and environmentally responsible. In 2015 he granted Berlin-based CUCULA, a Refugees Company for Crafts and Design, the rights to redesign and sell his Autoprogettazione furniture to raise funds for its refugee support programme.

Revered as a thought leader, teacher and theorist, Mari is widely acknowledged as one of the most influential designers of the 20th century.

A contemporary product that could be considered as an example of democratic design is Tiptoe table legs. Tiptoe is a French company that produces modular table legs that can be easily attached to a surface, allowing the user to create individual furniture in a few minutes without power tools.

Tiptoe legs can be purchased individually and can be clamped on to existing surfaces, such as an old table top or some sheet material, in a variety of sizes/ thicknesses facilitating the use and reuse of materials and components.

Tiptoe base their design on 5 sustainable principles of:

- Making things simple
- Making more with less
- Using the right materials
- Building to last
- Design for disassembly


95
BPM

7: Products that Deserve to Exist?

In a world where resources are becoming increasingly scarce, are there some products that do not deserve to exist?

In 2016, Silicon Valley Based start-up Juicero launched their cold press juicer system. The company had attracted $120m in funding since being founded in 2013. The Juicero system consisted of plastic pouches containing diced fruits and vegetables which could be ordered through a subscription system. The pouches would be inserted into a $400 Juicero press which mechanically squeezed the contents of packet into a juice. Despite the fact that the juice pouches had expiration dates printed on them, the Juicero required an internet connection in order to read a QR code on each pouch to check the if the product was in date. If not, the machine would not operate.

The company only sold about 3,000 units before folding in 2017 after users realised that the content of the pouches could just as easily be squeezed by hand, without any real requirement for a complex machine.

The Juicero story is an interesting and almost funny anecdote, but it points to a bigger problem; how could such an unnecessary and overly complex system get so far and attract so much funding?

Another product that has become increasingly prevalent in recent years is the disposable vape. Disposable vapes work by using electricity to power a heating element which in turn heats a liquid containing nicotine, turning it into vapour which is then inhaled by the user. These products are very difficult and expensive to recycle because they are made from a mixture of materials and components including a lithium battery and electronice parts such as the heating element and a pressure sensor. They are typically designed as one unit, which means the batteries can't be easily separated from the plastic shell and other materials.

In the UK nearly 5 million vapes are disposed of each week- that's is about 8 vapes every second. Some of these enter the environment as litter and while some go for recycling the majority end up in landfills. And even if disposable vapes were easier to recycle, our waste management systems can't handle the huge quantities of disposable vapes being thrown away every day.

These products also use a huge amount of valuable natural resources- for every vape sold, there are carbon emissions generated through the production of plastic, mining for materials, shipping and packaging. And the batteries within disposable vapes are precious lithium batteries that are being disposed of after a short period of use.

Disposable vapes were invented in order to reduce the amount of people smoking and associated health issues, which of course is a good thing. However as a society, we often resort to technology and products to solve problems but these solutions to one problem can, as we have seen, cause other problems.

So, in a resource poor world, what products do and don't deserve to exist?

Activity

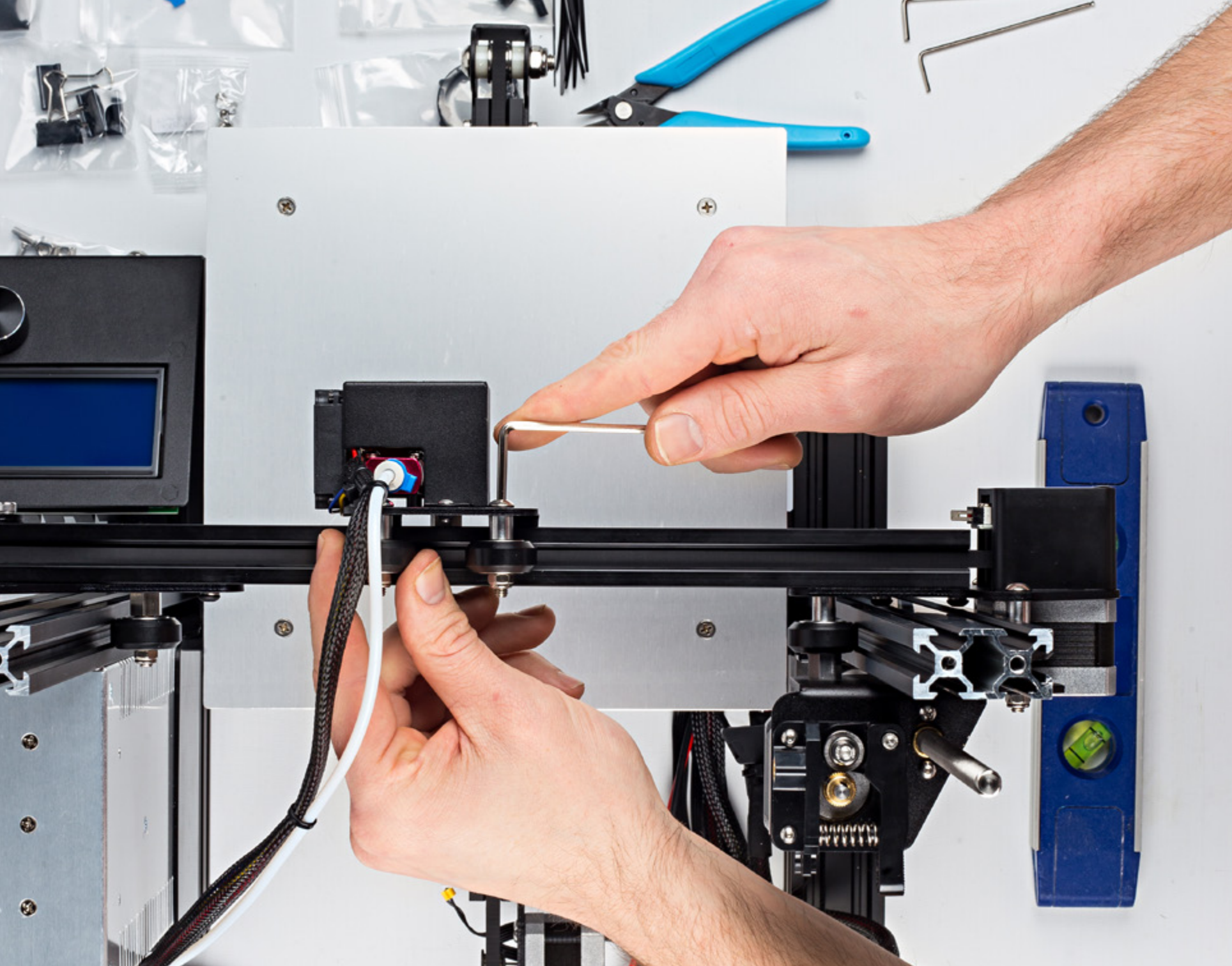
Products that Deserve to Exist

In this activity, students will consider and discuss whether certain products deserve to exist or not.

1. Working in teams of 3-4, students are dealt a number of product cards from the opposing page each. Working/ thinking individually first, students place their cards on the worksheet in the box that they think they should go.

2. Team members are then given two minutes to move any cards that they think are incorrectly positioned.

3. Teams discuss their decisions to try to come to agreement where possible on each product.



8: High-tech low-tech

Can high tech ever be low-tech?

If we think about low-tech, probably one of the last products that would come to mind would be a 3D printer; most people would probably consider 3D printers to be at the cutting edge of high tech. While it would be difficult to argue that a 3D printer in itself is low tech, could 3D Printing in some circumstances be considered an appropriate part of a low-tech system?

3D printing was originally developed in the 1980s as a process called Stereolithography (SLA). Stereolithography involves using a UV laser to polymerise and solidify a photosensitive resin, layer by layer. This process was highly complex, extremely delicate and required very expensive machines, at the time costing about €300k. By the mid-2000s, the price of 3D printers had reduced substantially, with Fused Deposition Modeling (FDM) printers becoming commercially available for less than €10k. FDM is a much simpler process whereby a plastic filament is melted and extruded layer by layer to make a part.

In 2005, Adrian Bowyer, a Lecturer from the University of Bath developed RepRap, a project that aimed to make low-cost FDM 3D printing available to everyone. RepRap printers were available open-source and could be built for a couple of hundred euros using reasonably easy to access components and parts built by the printer itself. Today 3D Printing has become increasingly democratised - both commercial and open-source 3D printers are available within this price range and the technology has become more accessible, more reliable, easier to use and in many respect increasingly low tech.

In terms of sustainability and low tech, 3D printing can a have many advantages over traditional manufacturing processes:

1. 3D printing can be used to repair and extend the life of products
2. It can support localised manufacturing – complex parts can be designed and made locally
3. It can reduce overproduction- parts can be printed as needed instead of mass production of stock that may never be required
4. It can support resilience by providing individuals or local communities with the ability to respond to local needs, reducing dependence external sources
5. There are many open-source communities that share knowledge and 3D printing files for a greater good
6. While 3D printed parts typically cannot be recycled commercially, they can be locally recycled back into 3D printing filament using a shredder and filament extruder
7. 3D Printing has parallels with some traditional making processes- unlike mass manufacturing processes such as injection moulding where all parts are identical, 3D printed parts are not made from a mould and can therefore be individualised to a particular need

Is it is Low-Tech?

As we have seen from the example of 3D printing, it can sometimes be unclear as to whether a product fits within the context of low-tech.

Some products may have atributes of low tech or some products might be be useful in supporting a more resilient low-tech society. It is important for us to be able to critically evaluate the appropriatness of a solution to a low-tech framwork.

The European Union Energy Label aims to inform consumers on the energy efficiency of a product. How might we assess the effectiveness of products in the context of low-tech? The activity below aims to develop students critical and analytical thinking competencies with regard to low-tech.

Activity

Low Tech Rating System

Usint the European Union Energy Label as inspiration, students will design a low-tech rating system that can be used to assess how well a product or solution conforms to low-tech thinking. The system should assess and rate a product, taking into account multiple low-tech factors and applying an alpha numerical rating across several categories and to the product as a whole.

Teams will test their rating system using at least 3 products.

Teams will iterate and improve theirrating system as necessary following testing.

Top: Lari Kitchen Scale by Theodore Simon
Bottom Right: Herman Miller Setu chair designed by Studio 7.5

9: Engineering Elegance & Monomaterials

How can we use materials technology to create more simple solutions?

In designing solutions to mechanical problems, such as the transmission of force, it is easy to default to complex solutions involving multiple parts, materials and connections.

If we take the example of a standard ergonomic office chair, these typically include multiple complex mechanisms that allow for adjustments such as seat height, seat tilting and back tilting and tension. These mechanisms often comprise of multiple complex manufactured assemblies and sub-assemblies, consisting of components such as actuators, pistons, springs, dampers, hinges, fixings etc.

In 2009, Berlin based Studio 7.5 designed the Setu chair for office furniture manufacturer Herman Miller. The chair was a departure from typical office chairs of the time in that the designers used inherent material properties and specifically designed geometry to replace several complex mechanical assemblies. Using the natural behavior and deformation of the material, the geometry of the beam and side profiles of the chair were specifically designed to provide flexibility where needed for users to lean back whilst also being supported, without the use of components such as gas pistons.

Although these chairs are highly complex in design and form, the result is a solution that contains fewer parts, less materials, is easier to disassemble and recycle and is much more lightweight than similar products.

Another example of elegant use of material geometry is the running blade (see image, page 70). These prosthetics are designed to allow amputees to exercise and compete in athletic events. Rather than trying to directly replicate a human leg with mechanical and electrical components, running blades use material properties and specifically designed geometry to replace or improve upon human running motion.

Today we are seeing increasing research into and use of these so called "compliant mechanisms". The area has been advanced by technologies such as 3D printing, CNC machining and laser cutting which enable us to create more complex geometries whilst making the design and testing of these mechanisms much more accessible.

Lari is a kitchen scale concept designed by Theodore Simon which stems from research into compliant mechanisms. The scale is made entirely from one material and consists of only two parts. The item to be weighed is placed on the tray which is linked to the base by two flexible parallel beams, allowing the tray to remain level. A flexible indicator is actuated by the movement of the tray which allows calibration to zero by sliding in the base. The scale combines the clever use of form with the natural elasticity of the material to transfer the force from the weighed item to the indicator.

By contrast to most kitchen scales today, Lari has no electronic components, requires no batteries or electricity, is made in only 1 material, simplifying production and facilitating recycling.

Compliant mechanisms have many advantages over traditional mechanisms in terms of sustainability:

- Many compliant mechanisms can be made from a single material, greatly enhancing recyclability
- Compliant mechanisms typically contain less materials, using less resources
- They are often lighter and sometimes more compact than traditional mechanisms which may have advantages for transport
- Compliant mechanism are typically less complex and therefore more energy efficient to manufacture than traditional mechanisms
- They have fewer moving parts which means less friction and less wear which may increase the lifespan of the mechanism.

Compliant mechanisms can have several other advantages too such as:

- Less assembly time
- Less material cost
- Less manufacturing cost
- High precision and suitability to miniaturisation

Of course there may be disadvantages to Compliant mechanisms too. In some cases, Compliant Mechanisms might be less robust or less durable and may not always be the appropriate solution.

Above: Clockwork Radio, Designed by Trevor Baylis

Above: Framework Laptop
Image: The Design Museum and the photographer Felix Speller.,

10: Case Studies

Clockwork Radio

In the early 1990s, Trevor Baylis, a movie stuntman turned inventor, was watching a television documentary about the spread the HIV virus in Africa. While watching the programme Baylis realised that communication of health information and education of the population in remote areas could help reduce the spreading of the disease. In many parts of rural Africa access to radios was limited, with access to electricity or batteries being a key part of the problem.

Following the programme, Baylis immediately started to prototype a clockwork radio using components he could find around his home including a small transistor radio, an electric motor from a toy car, and the clockwork mechanism from a music box.

The Clockwork Radio eventually went in to production in 1996 and is credited with providing life-saving information to millions of people in the developing world.

On many levels Baylis's radio might not be considered a low-tech device– it is mass manufactured using injection moulded plastic and electronics, but in use it is powered entirely by human effort and can provide vital and lifesaving information.

Activity

Using the Clockwork Radio for inspiration, what other products could be designed so that they could be powered by humans without the need for batteries or electricity?

Framework Laptop

Framework is a US laptop manufacturer founded in 2020. The company positions itself as a sustainable alternative to more prominent laptop manufacturers; Framework laptops are designed to be modular, upgradable, customisable and repairable in order to extend their lifespan and reduce electronic waste. Unlike many technology manufacturers, Framework is a proponent of the right to repair movement.

The Framework laptop is designed so that key parts such as screen, keyboard, battery, and motherboard can be easily replaced should they become damaged or out of date. Replacement parts can be purchased on a marketplace enabling users to keep their devices functional for a much longer period than traditional laptops. The laptop is specifically designed to make replacing parts easy using standard tools. Easy to follow instructions are also provided via QR codes on internal components.

Activity

Using the Framework Laptop as inspiration, what other devices could be better designed so that they can be easier to upgrade and have a longer functional life?

Above: Off-Cut Creatures by Studiomama: Wooden characters created from off-cuts and waste materials

10: Case Studies

Childrens toys

The shift from traditional children's toys, such as durable wooden toys, to mass-produced branded toys tied to popular TV shows has brought about significant changes from both a sustainability and child development perspective.

From a sustainability impact point of view. The shift in material quality has had a massive impact on children's toys sustainability. Traditional toys were often made from materials like wood and metal, those materials have intrinsic materials properties of durability and tend to have longer lifespans especially when compared to the many mass-produced toys today predominantly made of plastic. These plastic toys often lead to pollution problems due to their lack of reparability leading to them often being discarded to landfill.

These plastic children's toys are often branded with tv show/movie characters or trends, these shows and characters can often have short-lived popularity as children's interests change rapidly, there's a risk of these toys becoming disposable once the trend fades, contributing to a culture of overconsumption and waste.

In terms of production and transport the majority of children's toys are produced in eastern countries where large scale injection moulding facilities are widespread. Leading to the an increase life cycle carbon emissions of these toys when the materials and raw material acquisition/transport along with the increased product transport distances are taken into account.

Branded toys tied to specific TV shows might limit creative play by dictating certain storylines or scenarios, potentially hindering a child's ability to invent and explore on their own. Traditional toys often have a focus on simplicity and encourage developmental skills such as fine motor control, problem-solving, and spatial awareness. In contrast, some branded toys may prioritize entertainment value over educational benefits, potentially limiting the cognitive and developmental advantages children can gain from play.

In short, while mass-produced branded toys offer a child the opportunity to play with popular media and characters, they come with environmental concerns and potential drawbacks for child development when compared to the enduring appeal and educational benefits of traditional, sustainable toys. Striking a balance between entertainment, sustainability, and developmental value is essential for fostering a healthy play environment for children.

Activity

Project: low-tech toys
In teams for 2-4 students are challenged to create a set of children's toys for a 3-5 year old children. Teams should incorporate the low-tech mindset to create open play toys that children can use to create their own stories/games.

The toys should offer opportunity for the child(ren) to develop in mental or physical ways through open play / motor development

10: Case Studies

Footwear Design

The prevalence of the shoe cobbler in history and its decline in the last 20 to 30 years is an example of when society was in fact more low-tech and sustainable before being sustainable and eco-friendly was at the forefront of consumers minds and now, we have created footwear for the masses that neglects the qualities instilled over thousands of years.

In terms of construction and repairability even the cheaper shoes worn during the mid to late 20th century would be considered high end by today's standards. In order to get shoes that can be resoled and repaired the initial entry price and the types of shoes on offer just aren't suitable or practical for most people.

The historical significance of the shoe cobbler and the evolution of footwear construction provide a lens through which we can see the shifts in societal values, technology, and consumer tastes. The shoe cobbler held a crucial role in communities, emblematic of an era when craftsmanship and sustainability were intrinsic to daily life.

In the early to mid-20th century, shoes were often constructed with durability and repairability in mind. Cobbler shops were commonplace, offering a range of services from resoling to stitching, ensuring that people could extend the lifespan of their footwear. This approach aligned with a more resource-conscious and sustainable mindset, reflective of a society that valued longevity and quality over disposable convenience.

Over the last two decades, the landscape of the footwear industry has undergone a profound transformation. Mass production, globalization, and the rise of fast fashion have led to the rise of inexpensive, readily available shoes. Unfortunately, this shift has often come at the expense of craftsmanship and repairability within the local community.

Footwear manufacturing is driven by consumer demand for affordability and variety, with emphasis on materials and construction methods that prioritize cost efficiency over longevity. Many shoes are now designed with glued soles and synthetic materials, making repair challenging or impractical. As a result, the traditional cobbler's craft has declined and died out in many communities, signalling a broader societal shift towards disposable consumerism.

While there are still high-quality, repairable shoes available, they often come with a higher initial price tag. This poses a challenge for the average consumer, as the affordability and accessibility of durable, repairable footwear has diminished. The types of shoes on offer in mainstream markets often prioritize style and trends over practicality and longevity, contributing to a culture of disposability.

In short, the evolution of the footwear industry reflects a larger societal trend where convenience and short-term cost savings have taken precedence over long-term sustainability. As we navigate the path between modern consumer demands and the values of craftsmanship and durability, it becomes crucial to reconsider the true cost of our choices and explore avenues for a more balanced approach to fashion and consumption for a more sustainable long-term future.

Activity

Talking points

Taking the example of the shoe industry taking backwards step in the last 20 years, in groups discuss what other products or business models have taken a backwards step away from sustainability and prioritised a cheaper supply chain at the cost of the environment.

Open Design

Embracing openness and collaboration in designs

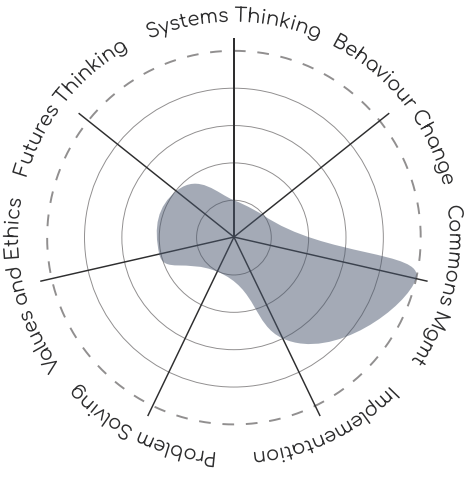
Sacha Hodencq & Kévin Loesle

2 lessons
1 Lecture, 1 Debate, 1 Project, 1 Workshop

Above: Retha Ferguson. Photo of Women at the Meeting. 2020. RF._studio. https://www.pexels.com/photo/photo-of-women-at-the-meeting-3811082/

Open Design

Embracing openness and collaboration in designs



Learning Hours		
To succesfully complete this module the learner will engage in:		
Activity	Activity Description	Hours
Debate	A structured debate exploring the benefits, challenges, and limitations of openness in design.	8
Lecture	Lectures introducing the context, stakes, and domain-specific knowledge related to Open Design.	3
Project	Hands-on project work involving documentation, governance, and dissemination, with significant self-directed learning.	2
Workshop	A debriefing session using popular education methods to help students adopt diverse perspectives on openness.	10

Module Objectives

The aim of the module is to introduce an open design approach as a design open for studying, modifying and replicating, as well as using and repairing. Such design is also intended to be accessible and inclusive regarding skills and finances. It can be applied to an item, a system, or an organisation to be shared and improved through various community uses and contributions. The learner will engage with the course contents through theoretical inputs and by putting in practice documentation, dissemination, and community governance.

Before starting...

Find some local examples that you can share with students

- of open designs
- of Commons

Make sure the students have a project to document

Learning Outcomes

Open Basics

Choose a relevant open licence and a relevant dissemination process

Understand accessibility in terms of knowledge, skills, tools, finance, and the concepts of universal and inclusive design for a project/system.

Understand the interests and practices of open documentation

Documentation & Dissemination

Select relevant open practices and justify this choice

Criticise existing practices of openness and governance

Write relevant and complete documentation for studying, using, modifying, replicating and repairing a solution

Provide accessible dissemination contents

Community Governance

Understand community-held knowledge systems and how to share and promote knowledge for collaboration.

Understand the concept and practices of the "Commons"

Above: Tima Miroshnichenko. A Girl Sitting in Front of a Table Between Database Wooden Drawer. 2021. https://www.pexels.com/photo/a-girl-sitting-in-front-of-a-table-between-database-wooden-drawer-6549629/

1: Open Basics

Foundations of Openness: Documentation, Hardware, and Inclusive Design

Open Documentation

One of the core features of Low-Tech is its accessibility. Accessible can be understood in terms of:

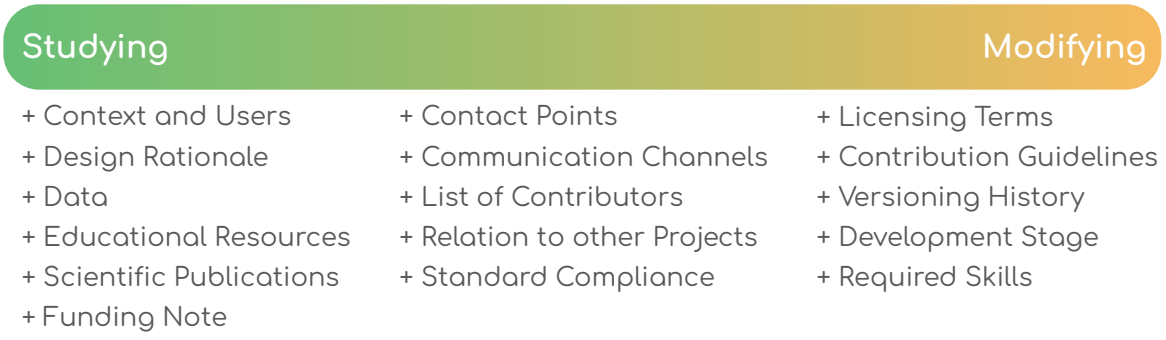
- Skills: The design is doable, and it requires limited skills.
- Finance: Low-tech outputs can be developed for free or with a limited budget.
- Knowledge: making knowledge open, accessible and understandable for anyone.

Documentation is an obvious practice in developing this *knowledge accessibility.* Documentation is destined to be useful both for the one documenting and for others. It enables the maker to keep track of their work and allows others to reproduce and contribute to what is documented. Yet knowledge accessibility necessary condition is not just documentation but **open documentation**, that is to say:

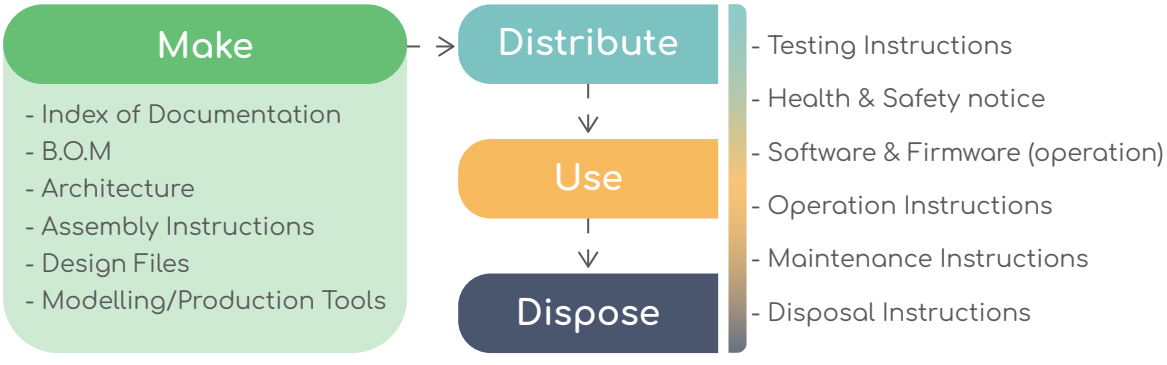
> Making the design available for anyone to study, modify, make, distribute, use and repair your work for any purpose with no restriction.

This definition is based on the open hardware freedoms (Powell, 2012).

In practice, opening up documentation means making it freely accessible, in an open format (i.e., not needing proprietary software to be accessed), and in an understandable and legible way. FAIR (Findable, Accessible, Interoperable, Reusable) principles can be applied (FORCE11, 2014), for instance, by offering a common vocabulary to describe data, software, or design through metadata (i.e., data describing other resources). Figures 1 and 2 present examples of metadata related to open hardware freedoms , that can be used as checklists according to the documentation aim.



Above:
Figure 1: Process-related metadata related to the open hardware freedoms



Above:
Figure 2: Product-related metadata related to the open hardware freedoms

Links to other content in the Book:
Sustainability: synergies exist between openness and sustainability, for instance the product passport from the EU: https://hadea.ec.europa.eu/calls-proposals/digital-product-passport_en

“Open Science is a concept promoting transparency, reproducibility, equity, and fairness in knowledge acquisition and dissemination for ecologically sustainable livelihood of a global society in accordance with Good Scientific Practice (GSP) by utilizing digital tools and services.”

Dr Jo Havemann
Perspectives Charter School, Chicago, United States

Documentation also depends on the target audience (e.g. developers, users, makers, educators) and the purpose of engaging, and so it can have many forms: manual, report, experiment notebook, user guide, article, or even story or interview. Examples can be found in the appendix.

Documentation also needs to be open legally, that is to say associated with an open licence. Licences enables authors to establish the conditions under which its work may be consulted, re-used and modified. A licence may apply to any type of content (e.g. design files, document, multimedia, software), and can vary from very open to very restrictive. The more restrictions there are, the more difficult it becomes to combine content published under different licences, which can hinder interoperability. Creative Commons are the best known, but tools can help in deciding which licence to choose[2],[3].

Open hardware and open science

Open hardware principles go beyond the sharing of open documentation:

- Accessible and modifiable format,
- Easily sourced components and materials, standard manufacturing processes, open infrastructures, royalty-free content and open-source design tools,
- Control over the technology,
- Co-construction, co-creation.

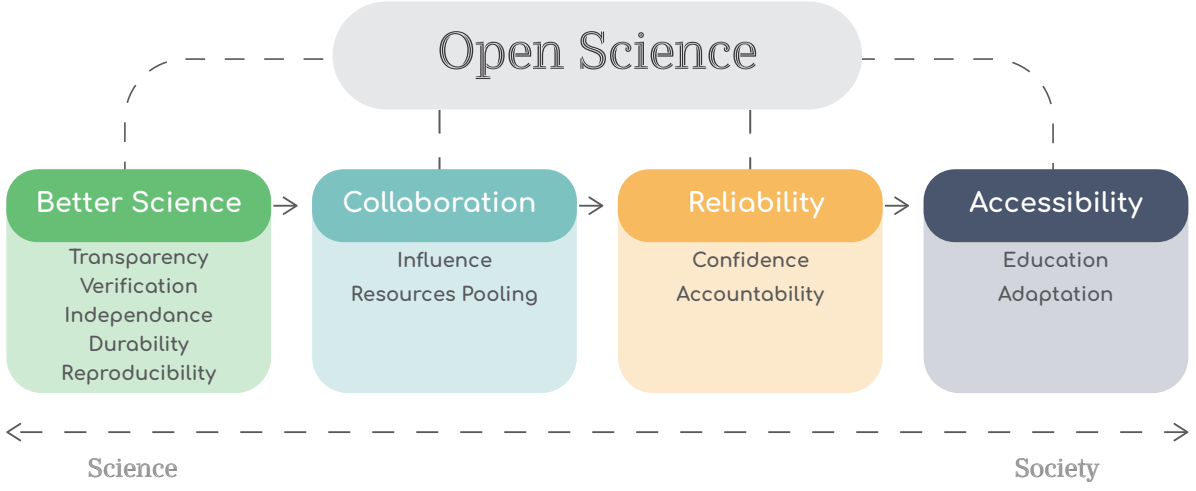
Open hardware is actually part of a wider movement called Open science.

Open science can be seen both as a movement to make science open for collaborations and contributions, where contents are freely available, under terms that enable:

- Reuse
- Redistribution
- Reproduction

and knowledge that is transparent and accessible and shared and developed through collaborative networks. Tackling the issues of opaqueness, parallel effort, trust crisis or barrier to adoption, it has many interests as presented in Figure 3. Open science is a new paradigm compared to mainstream practices, shifting from competition to collaboration and favouring reflexivity. It still faces lack of awareness and political incentives.

Open science fosters better quality science through transparency, reproducibility and verificaiton, as well as independance and durability of knowledge. It also improves collaboration and ressources pooling. Making knowledge transparent and accessible also increase the confidence the general public can have in it, and appears as a mission of accountability for public research. Finally, open science works can easily be used and adapted in education.



Above:
Figure 3: interests of open science

References and Further Reading:

[1.] Homepage - Creative Commons. (2023, November 16). Creative Commons. https://creativecommons.org/
[2.] Choose an open source license. (n.d.). Choose a License. https://choosealicense.com/

Links to other content in the Book:

Design for Resilience, Repairability, Reliability: the design methods can be linked to the open documentation of their items. The thinking about the audience of the design (in terms of inclusivity for instance) can also be directly related to the audience of the documentation.

Above: Ense[3]. PISTE students cooking food on an open source stove .2022. Grenoble.

Universal & inclusive design – Citizen science

Various methods are engaged for designs that are truly open to everyone.

Universal design:

The design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. "Universal design" shall not exclude assistive devices for particular groups of persons with disabilities where this is needed (Duncan, 2006; United Nations, 2006). It includes 7 principles that may be applied to evaluate existing designs, guide the design process and educate both designers and consumers about the characteristics of more usable products and environments. Universal design goes against the approaches too often used today to improve accessibility, which are based on obligations of means rather than results, and involve the implementation of prosthetic, functional and technical standards, applied without consideration of aesthetic quality.

Despite their initial aim of integration, these elements can stigmatise and contribute to the exclusion of people with disabilities (for example, disabled toilets, which create a "third gender"). Universal design is more widely used in tangible and environmental contexts.

Inclusive design (Joyce, 2022):

Methodologies to create products/services that understand and enable people of all backgrounds and abilities. It may address accessibility, age, economic situation, geographic location, language, race, and more. Inclusive design is applied more frequently to digital-product design.

In order to be truly effective with regards to universal and inclusive design, a designer must understand the specific needs of individuals. The earliest possible participation of the various groups concerned is necessary in the design process, so that they can share their experiences (Aslaksen et al., 1997). As a result, the design, or the research process itself can also be opened up. Participation process as the ones experienced in citizen science can play a significant role here.

Citizen science consists in opening up the processes of creating, evaluating and disseminating scientific knowledge to stakeholders in society beyond the traditional scientific community (UNESCO, 2021). It involves the creation of common goods and shared resources; knowledge transfer and Science-Society ties, and can improve the equal access to and dissemination of knowledge, as well as epistemic justice (i.e. ability to position as a producer of knowledge in discourse).

Both academic and experiential knowledge are valued for the definition of the problem and the different phases of research. The European Citizen Science Association (ECSA) provides 10 principles to carry out citizen science properly (ECSA, 2015).

Above: Ense[3]. PISTE students developing open documentation .2022. Grenoble.

2: Community governance

Community management and governance

Creating a community around a project means bringing together a group of people who share a common vision, culture, and history and who interact to achieve the common goals they have set themselves. Digitalisation can facilitate this. The community's raison d'être needs to be clearly and concisely explained (general presentation, who it is for, what can be found here, where more information can be found). A governance model must also be defined.

Governance is making and enforcing decisions within an organisation or society. It encompasses decision-making, rule-setting, and enforcement mechanisms to guide an organisation or society's functioning.

> For everyone to have the opportunity to be involved in a given group and to participate in its activities, the structure must be explicit, not implicit. Decision-making rules must be open and available to everyone, and this can happen only if they are formalised.
>
> Jo Freeman, The Tyranny of Structurelessness

The lack of a governance model can entail several issues: cohesion, disorganised contributions, unwanted behaviours or community conflicts. Especially as communities grow, coordination work becomes time-consuming. On the other hand, stringent rules deter newcomers. As a result, communities tend to develop governance models "ad hoc" once it is too late (Schneider et al., 2021). Governance elements are presented in Table 1, and several examples of governance models such as democratic, autocratic, and consensus-based models, and guides in their creation can be found on the CommunityRule website (Media Economies Design Lab, n.d.)

Choosing a governance model enables roles to be clearly defined and recognised. Procedures such as a code of conduct, ways to contribute, guidelines, and roadmap are also made explicit and shared, and communication tools are used accordingly.

Governance is a core element of the concept of "commons." Commons can be defined as a resource managed by a community abiding by a governance model. These resources can be physical, such as land or water, or non-physical, such as knowledge or information. The governance model ensures that the resource is used and maintained in a sustainable and equitable manner, as illustrated in Figure 5.

Above:
Figure 5: Commons core elements
from https://chambre.lescommuns.org/les-communs/

The Commons is an idea with considerable historical significance. In the Middle Ages, common lands were pastures and fields managed collectively without individual ownership, a testament to the power of community. These fields were privatised in England with the Enclosure Acts in the late 19th Century, marking a significant shift in the idea of community ownership. ecologist Garett Hardin theorised "The Tragedy of the commons" in an essay, stating that

> "A resource left free for use will be exhausted very quickly"
> (Hardin, 1968).

If this statement can be valid in the current paradigm, it is not a fatality. It actually calls for governance models for resources that should be collectively chosen.

Element	Description	Some Examples
Culture	What are the core missions, values, and norms?	Autonomy, Diversity, Solidarity, Origins, Purpose, etc.
Decision	Who can make decisions and how?	Consensus, Lazy Consensus, Approval voting, "Do-ocracy", Referendum, Proof of work, etc.
Process	How are policies implementted, and how do they evolve?	Accountability, Code of conduct, Debate, Meritocracy, Polling, Initiation, Petition, etc.
Structure	What kinds of roles and internal entities are there?	Board, Bureaucracy, Committee, Council, Roles, Executive, Ownership, etc.

Above:
Figure 4: Elements to be considered in governance models (Media Economies Design Lab, n.d.)

Above: Sean Church. Lifetrac II_12 | Lifetrac II_12 Album, August 22, 2010. Flickr. https://www.flickr.com/photos/sean_church/4918893875/in/album-72157624665572279

2: Community Governance

In 2009, Elinor Ostrom received the "Nobel Prize in Economics"for her analysis of economic governance, particularly the common good. Her empirical work highlights collective methods of exploitation that can be effective, fair and sustainable (Ostrom, 1990). Her research is particularly relevant to community governance as it provides insights into how communities can effectively manage common resources, ensuring their sustainability and equitable use. The commons combine environmental and democratic requirements with:

- The sustainability of modes of exploitation: the commons assert collective rights and are concerned with the upkeep of the resource and space.
- The importance of the self-organisation: commons are self-organising institutions capable of producing rules of use, and having mechanisms to ensure that the resource is not over-exploited, for future generations.

This self-regulation is a testament to the power of collective action and can serve as a source of motivation for community leaders and members.

Nowadays, the concept of commons widens with information commons, which can be defined as an information system (e.g. such as a physical library or online community) that exists to produce, conserve, and preserve information for current and future generations (e.g. open data, open source software, open access articles), Wikipedia being an emblematic example. The philosopher Alexandre Monnin also offered the concept of negative commons: a common with adverse effects (for instance, waste or nuclear power plants) that we will inherit in the future and must take care of (Monnin, 2021). These negative commons, while not resources in the traditional sense, impact populations and ecosystems and must be managed to mitigate their adverse effects.

Acknowledgements

This section is mainly based on the lesson "Open Science & Commons" developed by Sacha Hodencq (Low-Tech Lab – ENSE3) and Emmanuel Laurent (MYNE) from 2021 for master II engineering students in Grenoble INP (France).

It also includes lessons from TU Berlin lesson on open hardware developed by Robert Mies, Sacha Hodencq & Julieta Arancio in 2023.

It uses CC0 resources from the Open Science Training Handbook of the european project FOSTER.

Links to other content in the Book:

The Imperative of Responsibility: transparency, and the governance that comes with the Commons is also a matter of ethics, for instance regarding the responsibility and accountability of the engineers & designers of products and systems. The notions of inclusivity and accessibility are also related to those of justice (distributional justice, recognition justice and procedural justice).

Entrepreneurship: the development of business models around open designs and Commons is to be developed and disseminated

Territoire: links with the cosmolocalism approach through open hardware.

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6 Thinking Hats

D'Edward de Bono

PROCESS

(Organisation of Thought)

It is the facilitator, the organiser of the meeting, who channels ideas and exchanges between the other hats.
They set the starting framework and synthesise the outcome.
It is the blue of the sky that encompasses everything.

THE FACTS

(objective information)

The thinker presents facts purely and simply.
They provide the group with numbers and information.
This hat represents the cold objectivity of computers and paper. It embodies simplicity and minimalism.

NEGATIVES

(risks)

The thinker makes objections by highlighting the dangers and risks that threaten the idea's success.
They are the "devil's advocate."
This hat represents prudence and negative judgement.

POSITIVES

(benefits)

The thinker shares their dreams and boldest ideas.
Their comments are constructive and attempt to put into action the ideas suggested by others.
This hat represents the sun and optimism.

CREATIVITY

(all your ideas)

The thinker provokes and searches for alternative solutions.
They are inspired by lateral thinking, offering a different way of considering a problem.
They explore untrodden paths and propose new ideas.
This hat represents the fertility of plants and the seeds of ideas.

FEELINGS

(emotions)

The thinker expresses their emotions, feelings, intuitions, and hunches.
They do not need to justify themselves to the other hats.
This hat represents fire, passion, and intuition.

Class Activities

This activity helps teams think collaboratively and comprehensively by using Edward de Bono's Six Thinking Hats. Each hat represents a different mode of thinking, enabling participants to explore ideas systematically and evaluate outcomes effectively.

In the context of this activity, the focus is on guiding groups to critically and creatively examine the open documentation and knowledge-sharing aspects of their Low-Tech projects.

1. Preparation:

Arrange the workspace to be comfortable and inclusive, with chairs and tables in a circle so all participants can see each other.
Gather materials: worksheets or flip charts, coloured pens and markers, sticky notes (preferably in multiple colours), and a timer or stopwatch.
Consider starting with a warm-up activity (e.g., 10 minutes) to energise participants and set the tone.

2. Introduction (5 mins)

Begin by explaining the purpose of the activity:

- Explore open documentation and knowledge sharing in Low-Tech projects.
- Generate diverse perspectives to evaluate risks, opportunities, and strategies.
- Establish ground rules:
- Ideas may be contradictory; this is part of the process.
- Focus on active listening, constructive input, and respect for all views.

3. Hat Sequences

For each hat, set 5 minutes for discussion and idea generation. Transition smoothly between hats, providing context for each:

Blue Hat: Process/Organising Thoughts

Begin by structuring the discussion. Decide roles, set timeframes, and outline key topics to focus on.

White Hat: Facts/Neutrality

Focus on objective elements:

- What factual information supports open documentation and commons in the project?
- Identify existing resources and gaps.

Yellow Hat: Positives/Benefits

Identify opportunities, strengths, and potential benefits:

- What long-term benefits can we envision for the community
- What opportunities arise from sharing knowledge openly?

Black Hat: Judgement/Negative Criticism

Explore potential risks:

- What challenges or failures could arise in making knowledge open?
- Are there specific areas of concern?

Green Hat: Creativity/New Ideas

Brainstorm innovative approaches:

- How can documentation be made more accessible or impactful?
- Explore novel methods for knowledge sharing.

Red Hat: Intuition/Emotions

Reflect on personal and collective feelings:

- What are your intuitive thoughts about the project's direction?
- Are these intuitions shared or diverse within the group?

Blue Hat: Process/Consolidation

Summarise and synthesise ideas

- Create a final poster capturing the main points and priorities.
- Identify 2–3 key takeaways to share in the presentation.

4. Debrief and Closing (5 mins)

Conclude with a reflective discussion where each participant shares their experience using the method.

The Three R's

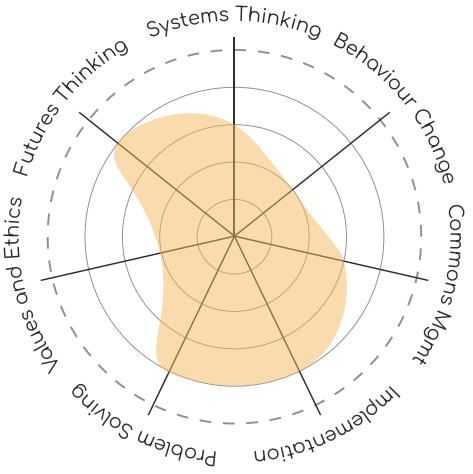
Reliability, Repairability, Resilience

Ceri Almrott

7 lessons
3 Self-directed Student Assignments

Above: Clark Young. man inside tool shed. September 2016. Unsplash. https://unsplash.com/photos/man-inside-tool-shed-fQxMGkYXqFU

The Three R's
Reliability, Repairability, Resilience



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	A series of classes introducing the core concepts of Reliability, Repairability, and Resilience, covering topics such as material properties, design strategies for longevity, repairability frameworks, resilience in systems, and emotionally durable design.	20
Self-Directed	Online Assessment of the Three R's: A formative assessment to test learners' understanding of theoretical concepts related to Reliability, Repairability, and Resilience. Product Case Study Assignment: An individual or group activity requiring learners to critically analyse an existing product's reliability, repairability, and resilience features Hackathon Project: A hands-on, team-based activity where learners design and prototype a low-tech solution that demonstrates reliability, repairability, and resilience	30

Module Objectives

This module aims to provide learners with a broad understanding of the sustainability concepts of Reliability, Repairability and Resilience within the context of low-tech development. It will equip students with the knowledge required to understand, analyse and assess low-tech projects and engage with theoretical models of the Three R's. Learners will be able to apply this theory to their project work to prove their understanding and improve their low-tech practice.

Learning Outcomes

Reliability

- Describe material properties in terms of their appropriateness for longevity.
- Understand the relationship between durability and material efficiency.
- Understand the concept of Design for Reliability within the low-tech context.

Repairability

- Understand the concept of design for repair and how it can be applied in Low-Tech projects.
- Explain the benefits of the right to repair and its integration within Low-Tech development.
- Develop an applicable design for repairability.

Resilience

- Understand and explain the concept of Emotionally Durable design.
- Develop solutions which can continue to function after abnormal events and uses.
- Undertake a user analysis and explain the core functions of a designed system to identify opportunities to improve its resilience.

Above: Mihaela Radu. A fairytale chair - Thonet Bistro Chair no.14. May 2018. https://revistadinlemn.ro/en/2018/05/18/a-fairytale-thonet-bistro-chair-no-14/

Left: Vinicius Benedit. Moka Pot brewing coffee. August 2020. Unsplash. https://tinyurl.com/4sku3w4b

Right: Fredrik Posse. a car parked in front of a building July 2022. Unsplash. https://tinyurl.com/4v8bpvct

1: Introduction to the Three R's

The Three Rs of Sustainability versus the Three Rs of Low-Tech.

The three Rs of sustainability are principles aimed at promoting environmentally responsible behaviours and reducing the negative impact of human activities on the planet. These principles focus on waste reduction, resource conservation, and sustainable consumption. The Three Rs are:

Reduce:

This principle emphasises the importance of reducing waste and consumption daily.
"Minimising our consumption by opting for products with minimal packaging, avoiding single-use items, and making conscious decisions about our needs versus wants can reduce the demand for resources, energy, and materials."[1].

Reuse:

Reusing involves extending the lifespan of products and materials, reducing the need for new resources to be extracted and manufactured. Reuse items multiple times before discarding them. Use reusable water bottles, shopping bags, and containers. Repair broken items instead of replacing them and repurpose objects for different uses. The goal is to keep items in circulation as long as possible before they become waste. [2]

Recycle:

Recycling is a process that recovers valuable resources from waste, reducing the need for virgin materials and lowering energy consumption and greenhouse gas emissions. It helps close the loop in a product's lifecycle and reduces the strain on natural ecosystems.

Collectively, these principles promote a more sustainable and responsible approach to consumption and waste management, aiming to lessen our environmental impact and create a healthier, more balanced relationship between humans and the planet. Within the Low-Tech framework, when considering the design and implementation of solutions, we can consider an added or alternative Three R's, which will help to ensure that the items we design are appropriate and applicable to the communities we are designing for. The Three Rs for Low-Tech for sustainability are:

Reliable:

Solutions that work reliably for every user, considering their technical and social scope of use. Reliable solutions are those people trust and consistently solve the problem they intend to.

Example:

The Moka Pot is a stovetop espresso maker designed by Luigi DiPonti in 1933 and produced by Bialetti. It is a simple, compact, and enduring kitchen tool that has become an iconic design and staple of Italian Coffee Culture. The Moka pot's design is straightforward, consisting of a few essential components that make it easy to use and maintain. It is produced from durable materials such as aluminium or stainless steel, making it heat-resistant and mechanically robust. Its brewing method is exceedingly simple and consistent, making it reliable and accessible to many consumers.[3]

Repairable:

Designs should prioritise repairability to ensure sustainability. Adequate interventions should be included in the economic and product design to empower users to fix objects when they fail.

Example:

The Citroën 2CV was designed to be a simple, affordable, and versatile car that was easy to maintain and repair. Its minimalistic features, modular design, and easy access to crucial components made repairs relatively easy. Citroën also supplied comprehensive repair manuals and guides, and the car used standard tools and fasteners that were widely available[4]

Resilient:

Resilient designs are built to last. They can withstand use beyond their intended limits and are created with longevity in mind. Designers consider how the design will age and how it can continue to be useful beyond the first owner's needs. This requires a deep understanding of the solution's use and human desires.

Example:

The Thonet café chair, also known as the No. 14 chair, is a classic of functional furniture design that has stood the test of time due to its resilience and durability. Designed by Michael Thonet in the mid-19th century, this bentwood chair is still an iconic piece of furniture that embodies several vital qualities of resilience. The chair's innovative manufacturing technique made the frame solid and flexible, a perfect combination for the rigours of life in a busy commercial setting. Its simple construction reduces the risk of parts breaking or wearing out quickly, making it a long-lasting and environmentally friendly option. The No.14's versatility allows it to be used in various settings, from cafes and restaurants to homes and public spaces, making it a timeless design that is still aesthetically appealing across generations and different interior styles.[5]

Links to other content in the Book:

Design for Sustainability - pg39

References and Further Reading:

[1.] Practical Action, 2022. The 6 R's. [Online]. Available at: https://practicalaction.org/the-6-rs
[2.] Ellen MacArthur Foundation, Unlocking a reuse revolution: scaling returnable packaging (2023)
[3.] Maltoni, E. 2020. Coffee Makers. Collezione.
[4.] Bobbit, M. 2019. Citroën 2CV: Different is Everything. Amberley Publishing
[5.] Schäfer, L. 2018. The Thonet Brand. Niggli.

The Three R's

Class 1 - Introduction to the Three R's

Worksheet 1

Unreliable Things

Photograph of a product you own

Describe the product. What is it? What is it used for?

What makes this product unreliable?

Interventions

Photograph of an intervention you have made

How have you attempted to improve the reliability of the product?

Photograph of an intervention you have made

How have you attempted to improve the reliability of the product?

Download Worksheet from DOI: 10.5281/zenodo.14621500

Class Activities

The following discussions should occur during or after the class to allow learners to reflect on their first understanding of the concepts introduced. An online tool like Padlet enables the class to build a knowledge bank and create a discussion around each example. However, this could also be conducted in a seminar-style roundtable where learners could show examples of their choices.

1. Can you think of a product that you have used that you would class as unreliable?

- Using the [PADLET] post an image or video of your product and explain:
- What made it unreliable for you?
- Did you come up with any solutions to make it more reliable?

2. What was the last thing that you repaired or attempted to repair?

- Using the [PADLET] post an image or video of your product and the repair if it is visible.
- What did you have to do to repair your item? Why did you choose to repair it?
- Was this an easy repair to make and what aided or made it difficult?

3. What is an object that you own that shows resilience in its design?

- Using the [PADLET] post an image or video of your object.
- What about the design of your object makes it resilient? Is it the material choice? Its emotional value or its ability to withstand misuse?

Above: Pavel Danilyuk. A person pouring milk into a bowl. March 2021. Pexels https://www.pexels.com/photo/a-person-pouring-milk-in-a-bowl-6996337/

2: What is Reliability?

How is it defined, and how do we prioritise it?

What makes for a reliable design?

When we consider something reliable, we discuss it in terms of being dependable, consistent and trustworthy at performing specific tasks or functions. In most contexts, reliability measures a system or object's ability to function and perform as intended without unexpected or unexplained failures or errors.
We can consider reliability within the following parameters:

- Engineering or technological
- Service and Infrastructure
- Human and Social

In engineering terms, we usually refer to reliability within a specific set of conditions and over a specified period. This is the most straightforward framework to grasp initially, as we are all innately familiar with using an object repeatedly and with the product failing when we remove it from its specific use boundaries.

When considering service or infrastructure models, we are moving away from relatively simple engineering boundaries where we measure a simple metric, such as durability, ductility, etc., and more into more complex system issues where many different actions could contribute to a failure. However, system-based solutions are becoming more habitual. As such, the designer must consider how the various elements within the system or infrastructure will work together to supply a service that a user can trust to deliver.

Finally, a reliable design from a human and social point of view is one where a large majority, if not all, users can easily find, interact and use the solution. To achieve this, the designer will consider the technical and social system boundaries to ensure the solution is safe, understandable and usable for all.

Low-tech development aims to create solutions users feel empowered and encouraged to use repeatedly, so technical reliability is crucial to achieving these goals.

We can further dissect our understanding of reliability into the following subcategories:

- Functional Reliability
- Durability
- Consistency & Predictability

When we prioritise reliability in a design, we decide to ensure that users can depend on our solution's performance, minimising the likelihood of failures, downtime, or negative user experiences.

Functional Reliability

Functional reliability is crucial for a product's success, as it affects user satisfaction and safety. It refers to a solution's ability to perform its intended functions consistently and accurately without failure or variance. A highly functionally reliable design builds trust in the product and aligns with user expectations while being intuitive and usable by everyone. It extends over the product's entire lifecycle, and designers must consider its performance over time, usage, and wear and tear.

Durability

Durability is the ability of a product to withstand wear, stress, and external forces over time without significant deterioration or loss of functionality. Suitable materials must be selected to engineer a durable product, and forces that affect the design must be considered. It's also important to understand the design's social and use factors and consider how users may misuse or find alternative uses for the product.

Consistency & Predictability

Consistency in design is essential to create a seamless and harmonious user experience. It helps users navigate and interact with products more effectively. Visual elements, user interactions, and overall product experience should remain predictable and unified. Clear and consistent feedback should be provided to the user. A consistent design reduces the learning curve for unaccustomed users, making the design more accessible to everyone.

How do designers prioritise reliability?

To prioritise reliability, designers must collaborate, test thoroughly and adopt user-centred design approaches. By focusing on these considerations, designers can create products that consistently meet user expectations. Especially within low-tech solutions, designers must focus on the whole system and each component, paying particular attention to user interaction and physical touchpoints to address reliability issues.

To increase reliability, carefully consider material choices. Focus on the solution's technical boundaries, use, and potential misuse. Choose high-quality, durable materials that withstand wear, impact, and any other relevant environmental factors, such as corrosion resistance, strength, and longevity.

Simplify the design and reduce complexity to minimise potential points of failure. Focus on creating a perfect solution to the problem without adding too many features. Consult with users and consider manufacturing and maintenance during the design process.

Links to other content in the Book:
Effectiveness, Efficiency, Sobriety pg.147

References and Further Reading:

[6.] Design for Reliability: Overview of the process and applicable techniques. (n.d.). HBK World. https://www.hbkworld.com/en/knowledge/resource-center/articles/design-for-reliability-overview-of-the-process-and-applicable-techniques#:~:text=First%2C%20let%20us%20start%20with,without%20failure%20under%20specified%20conditions.

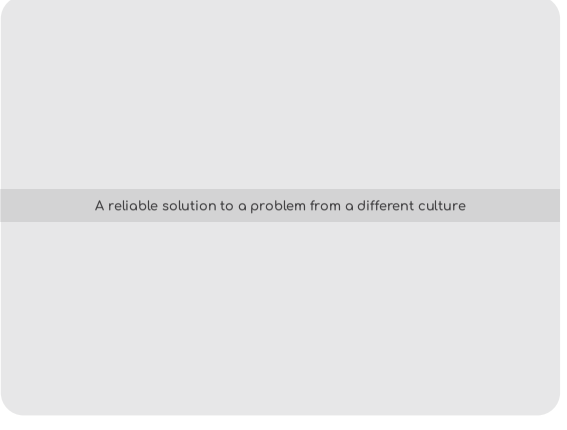
The Three R's

Class 2 - What is reliability?

Worksheet 1

Alternative Approaches

1. Place a photograph in the centre of the page of a reliable solution from a different culture.
2. Annotate and make notes around the image of how local resources and local practices have influnced the outcome and made it reliable.
3. Share back your findings and ideas with the group. Is there anything different you could consider or add to your own ideas?



A reliable solution to a problem from a different culture

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2: What is Reliability?

Case Study:
KitchenAid Model K Stand Mixer

KitchenAid's Model K Stand Mixer is a versatile and powerful appliance used in households and professional kitchens. It can work with a wide variety of attachments, making it a must-have tool for chefs and bakers alike.

The mixer, designed in 1937 by Egmont Arens, has a cast Zinc housing with an enamel coating. Its weight ensures stability on the worktop, and the enamel coating is hardwearing yet easily cleaned, requiring minimal maintenance.

The machine's powerful electric motor has simple controls that allow the user to adjust the mixing speed easily. This provides for efficient mixing, even with demanding tasks like dough making. The planetary drive arrangement ensures that all ingredients are efficiently combined, increasing the mixer's reliability for a perfect output.

Class Activities

The following activities should occur during or after the class to allow learners to reflect on their initial understanding of reliability in low-tech products. An online tool like Padlet enables the class to build a knowledge bank and discuss each example. However, this could also be conducted in a seminar-style roundtable, where learners could show examples of their choices.

1. Explore how different cultures have historically created reliable low-tech products suited to their specific environments

Discuss how cultural practices and local resources influence product design and reliability. Students can research and present case studies from diverse cultures via in-class presentations or a sharing tool like Padlet.

2. Encourage students to document low-tech solutions in their local communities.

This can include traditional tools, crafts, or techniques local artisans use. Students can interview community members, take photographs, and create presentations highlighting these reliable low-tech solutions. Findings should be presented on a knowledge bank tool like Padlet.

3. Assignment Task
For student's redesign project.

Students should choose a mid complexity technology product, such as a hand tool or basic household product for this assignment.

Ask each student to redesign the product to enhance its reliability while keeping the design as low-tech as possible. Students should document their reliability interventions in their design portfolio.

Above: Andrea Piacquadio Photo of Man Making an Acoustic Guitar. February 2020. Pexels. https://www.pexels.com/photo/photo-of-man-making-an-acoustic-guitar-3811843/

3: Designing reliable low-tech

How is it defined, and how do we prioritise it?

Designers must focus on reliability when creating products. This means incorporating reliability-focused interventions into the design from the beginning of the conceptualisation phase. The Low-Tech for Sustainability course can help designers develop a framework for their ideas, enabling them to approach their work with a reliability-focused approach.[7]

User-Centred Design

User-centred design is a crucial aspect of developing a reliable and user-friendly solution. It involves integrating user insights, iterative feedback, and inclusivity into the design process from the beginning of the project. By adopting this approach, designers can gain a strong understanding of a user's primary needs and how they might interact with the solution. This understanding enables the designers to pre-empt user behaviour and optimise the design for their needs. Furthermore, by thoroughly understanding the user's behaviour, designers can ensure that the optimisation is applied in the correct places, making the design intuitive and user-friendly. A user-centric design approach reduces the risk of incorrect usage that could lead to failure.

Simple Design:

The module, The Art of Simplicity, highlights the importance of prioritising simplicity in design to ensure reliable solutions. Simple designs with fewer parts and components minimise the chances of mechanical failures. Simplification makes understanding, troubleshooting, and maintaining systems easier, leading to increased reliability. Simplified designs are also easier to manufacture with precision and are less prone to assembly errors .

Robust Material Selection

Product durability and reliability depend on the materials used. Designers should choose high-quality, long-lasting materials that resist wear and environmental factors. It is crucial to select appropriate materials for each component. Locally produced materials should primarily be considered in low-tech designs, as this increases the territory's autonomy.

Testing

Testing helps identify defects in the solution before it reaches users. A robust testing approach ensures that the design output serves actors well. Testing verifies that the product performs its intended functions efficiently. By identifying weaknesses through testing, designers can enhance the product's design and materials, making it more reliable over the long term.

Reliability Testing

Reliability testing determines a product's likelihood of performing without failure for a specified time under defined conditions. It helps designers understand the solution's stability and consistency over time by identifying potential failure points. It often involves accelerated life testing, stress testing and failure mode analysis to predict the product's reaction to use.

Longevity Testing

Longevity testing assesses a product's ability to maintain its performance and functionality over time. Its goal is to identify issues with continuous use and provide designers with data on how the product interacts with real-world users and environments. This helps improve designs and understand material impacts.

Durability Testing

Durability testing evaluates a product's ability to withstand repeated usage, stress, and environmental factors without performance degradation. It focuses on resistance to damage and environmental conditions, using mechanical testing and simulation to determine resilience in abnormal use cases.

Maintenance and Use

Low-tech solutions often rely on simple mechanisms, which require regular maintenance to function as intended. Correct maintenance increases a mechanism's lifespan, reducing environmental impact. A maintenance culture can be developed within a territory through the organisation of community actions like repair cafes.

Ease of Maintenance:

When creating a solution's architecture, it's essential to consider how easy it will be to maintain and repair. End-users should be able to replace components without any difficulty whenever needed. Critical parts requiring maintenance should be easily accessible. The design should avoid the need for complicated disassembly or specialised tools for basic maintenance tasks.

Designs must be easy to assemble and disassemble without requiring specialised tools. Tool-free solutions encourage users to perform simple repairs independently and make maintenance tasks more straightforward. Designers should avoid permanent fixing solutions for components that may require repairs. By integrating universal components and standard fasteners, designers can guarantee that replacement parts are readily available and that maintenance tasks are simplified for users.

Links to other content in the Book:
Design for Sustainability - pg39
Art of Simplicity - pg.65

References and Further Reading:
[7.] Colin, C., & Martin, A. (2023). The user experience of low-techs: from user problems to design principles. HAL Open Science. https://doi.org/10.5555/3604890.3604892

Above: E.C.E. carpentry tools .The tool catalog. 2017.
https://ecemmerich.de/wp-content/uploads/E.C.E.-Werkzeugkatalog-2017.pdf

3: Designing reliable Low-Tech

When developing a solution, it's crucial to create user manuals that are clear and detailed, including step-by-step instructions for maintenance. It is essential to assist users in identifying and resolving common issues, including product visuals, diagrams, and troubleshooting guides. These resources should be provided with the product and available online in a communal location. When creating these resources, it's essential to consider the medium, such as video tutorials or FAQs, to ensure they are accessible to a wide range of users. For further information on open documentation approaches, please refer to the module Open Design.

Reducing the requirement for maintenance

Designers should strive to create solutions that require minimal or no maintenance. This can be achieved by prioritising passive systems that rely on natural processes rather than intricate mechanisms or external power sources. Utilising the power of gravity, capillary action, and other natural phenomena can help perform tasks without needing maintenance-intensive components.

To further reduce the need for maintenance, designers should evaluate how the product is likely to be used and identify primary wear surfaces. Materials with inherent lubricating properties should be used for these areas as this will reduce the likelihood of requiring maintenance. Increasing the thickness of wear surfaces can also help them resist wear for longer, lessening the need for regular external lubrication.

Proper weatherproofing measures, such as seals, gaskets, and coatings, protect products from water and UV damage. Critical components should be sealed to prevent foreign objects from entering vital systems, which could shorten the system's lifespan. Understanding Ingress Protection methods can help achieve this.

Finally, designers should reinforce joints and stress points to prevent wear-related failures and maximise durability. Proper engineering can evenly distribute stress, reducing the likelihood of wear in specific areas. By considering all these factors, designers can create solutions that are easy to maintain, long-lasting, and reliable.

By incorporating these strategies, designers can create low-tech products that are robust and reliable and require minimal maintenance, reducing users' burden and ensuring long-lasting functionality.

Case Study:
E.C. Emmerich

E.C. Emmerich is a distinguished German woodworking tool manufacturer celebrated for its exceptional wooden carpentry planes. Founded in the 19th century by a skilled carpenter renowned for his plane-making prowess, ECE has never dabbled in metal hand planes. According to the company, wood offers superior reliability, smooth sliding, and non-destructive contact with workpieces. Additionally, wooden planes are lighter than their metal counterparts, reducing fatigue during extended use.

Located near Düsseldorf, E.C. Emmerich's Hasten factory produces hand planes crafted from locally sourced Beech and Hornbeam wood. While most components are made on-site, metal parts are locally manufactured to ensure the highest quality. ECE is an example of how manufacturers can prioritise utilising local resources in developing their products.

ECE designs are user-centric, simple, and constructed from durable materials. Developed over many years and iterations, these tools require minimal maintenance.[8]

Links to other content in the Book:
Open Design - pg.93

References and Further Reading:
[8.] Laura Kampf. (2023, June 18). Inside a 170 year old Workshop. . .(how hand planes are made) [Video]. YouTube. https://www.youtube.com/watch?v=hooec53MqLQ

The Three R's

Class 3 - Reliable low-tech solutions

Worksheet 1

Prototype Testing

1. Bring your prototype to members of your community and ask them to explore and test the idea. Give them specific tasks to do with the prototype so you can compare the results amongst different users.

I LIKE...

Encourage your participants to convey aspects that they liked about the prototype. This provides you with positive feedback about your prototype.

2. Once you have run through your test procedure with your prototype ask your testers to provide you some feedback. Use the framework below and record their responses on post-it notes so they can be arranged later.

I WISH...

Prompt participants to share ideas of how the prototype can be changed or improved to address their concerns.

3. Analyse the results of your test, what have you learned? Look at the notes you have made and group any that are the same. Are there any strong themes or connections between the feedback you have been provided?

WHAT IF...

Ask participants to express new suggestions that might not have a direct link to the prototype. This opens up possibilities for new ideas that your team can explore in future iterations.

Download Worksheet from DOI: 10.5281/zenodo.14621500

Class Activities

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- What did you have to do to repair your item? Why did you choose to repair it?
- Was this an easy repair to make and what aided or made it difficult?

3. What is an object that you own that shows resilience in its design?

- Using the [PADLET] post an image or video of your object.
- What about the design of your object makes it resilient? Is it the material choice? Its emotional value or its ability to withstand misuse?

Above: Fairphone. E-Waste Recycling, June 2022. Fairphone Flickr Account. https://flic.kr/p/2oovKwS

4: The Right to Repair

Designing to empower autonomy and longevity

What makes for a repairable design?

When designing a product or system, it's crucial to consider its repairability. A repairable design can significantly extend a product's lifespan, promoting sustainability by reducing waste and conserving resources.

When designing a repairable solution, it's prudent to consider the system's function and how this affects the ease of repair early in the design phase. Designers should focus not only on the accessibility of system components but also on other factors such as documentation, the ability of the repairer to diagnose faults, and a user's ability to understand how their actions can affect the system. Standardisation, safety, and the appropriateness of repairs are also crucial elements to be considered during the design process.

While some people have an innate ability to understand how a device works and how it could be fixed, most people don't. Thus, design choices should empower as many people as possible to perform repairs. It is essential to consider the skill level of the average user and how best to communicate the knowledge necessary for them to undertake a repair.

Designs should effectively convey to the repairer how modifications and alterations can affect the product system. Designers should communicate information such as the need to remove extra components for proper repair or service or the specific sequence required to conduct the repair accurately. The timing and method of communicating this information should be part of the product's vision. Colour and texture coding, product semantics, material choice, and instructions can all aid in the identification and understanding of the various systems in a design.

It's important to note that specific parts of some solutions may not be safe or suitable for an untrained user to tackle independently. Designers must determine which systems and components should be accessible to the user and which should not. In some cases, repairing these parts may be possible through a community resource, such as a repair café, while in other cases, the parts may need to be discarded into the waste stream. If this is the case, then proper procedures for the disposal of these components should be communicated.

Designing products with repairability in mind is an essential aspect of sustainability but also aids in overall user satisfaction. Designers can play a significant role in encouraging and supporting repairability by advocating for more repairable product designs, engaging with relevant stakeholders, and considering the repair of their designs during the detailed design phase. Designing repairable products is essential to reducing a design intervention's environmental impact.

The right to repair.

Designers can encourage repairability by advocating for repairable product designs, engaging with stakeholders, and considering repair during the design phase. The Right to Repair movement aims to empower consumers and independent repair businesses by providing access to repair information, spare parts, and tools in response to manufacturers creating products that are intentionally difficult to repair. [9]

Designers embracing consumers' right to repair without unnecessary restrictions from manufacturers leads to a sustainable, consumer-friendly approach that reduces waste and promotes local economies. This approach combines design innovation, environmental consciousness, and advocacy for consumer freedoms.

Design for Repairability

"Design for Disassembly" is a sustainable approach crucial for supporting the Right-to-Repair movement. It enables designers to create products that are easy to repair and recycle. A comprehensive and cohesive approach is necessary to ensure all design elements facilitate easy dismantling.

When designing a product, it's important to consider how easy it is to assemble and disassemble. The parts that need servicing should be easy to take apart using standard tools without requiring specialised equipment or excessive force. Components that can't be repaired for safety reasons should be made replaceable, and it should be clear to the repairer that this is the case. The design should facilitate the disassembly process, making material recovery quick and reducing the likelihood of further damage if the user repairs the item instead of discarding it.

Adhesives are a quick and efficient way to assemble things, but they can make it tricky to take things apart. As designers, we should limit the use of adhesives because they can make repairs difficult. If we must use adhesive, we should opt for those that are easy to remove or reversible, such as thermal-based glues. This will make it easier to take things apart without causing damage during repairs or disassembly.

Links to other content in the Book:
Design for Sustainability - pg39

References and Further Reading:
[9.] Saidani, M., Kim, A., & Kim, M. (2023). THE RIGHT-TO-REPAIR MOVEMENT AND SUSTAINABLE DESIGN IMPLICATIONS: a FOCUS ON THREE INDUSTRIAL SECTORS. Proceedings of the Design Society, 3, 3463–3472. https://doi.org/10.1017/pds.2023.347

Above: Fairphone. FP4-Green-Exploded. September 2021. Fairphone Flickr Account. https://flic.kr/p/2mvYPRx

4: The Right to Repair

Modular Design

Designing products with a modular architecture is essential to make them easy to repair. By incorporating modular design principles, designers can significantly reduce users' difficulty in diagnosing and fixing issues with a device's functionality. This results in much more user-friendly and easily serviceable products. Modularity can be considered at the component level or as subsystems within a product. Indicating to users which components contribute to which subsystems will make repair tasks much easier to understand.

Modularity at the component level allows specific parts to be replaced instead of the entire product being disposed of due to critical failure. This approach was once standard but has been replaced to enhance manufacturing efficiency and reduce product size. Standardised components in a modular system have multiple benefits. They make replacement parts more accessible and allow users to replace or upgrade modules, enhancing the product's functionality and lifespan.

Incorporating modular design principles empowers both consumers and repair technicians. It allows users to replace faulty components without expert knowledge, promoting self-repair and reducing electronic waste. Technicians benefit from simplified diagnostic processes that ensure efficient and targeted repairs. Ultimately, this approach fosters repairability and champions sustainability.

Documentation

Complete documentation is vital for product repairability. It helps users and repairers diagnose and fix issues efficiently, promoting a more sustainable consumer culture. Clear and accessible documents are crucial for repairing all our products. These manuals should offer detailed instructions, illustrative diagrams, and comprehensive parts lists to provide a clear roadmap for repairers. They serve as invaluable references, ensuring that users and repair technicians have the necessary guidance at every stage of the repair process. With such guidance, repairers can navigate the product's intricacies, making the repair process accessible. Clarity in documentation simplifies repairs and encourages users to self-repair, promoting a more sustainable and empowered consumer base.

By supporting open-source initiatives, manufacturers can improve the repairability of their products. One way they can do this is by releasing design schematics, firmware, or software as open source and inviting collaboration from the community. This openness empowers people to come up with custom repair strategies and extend the lifespan of products. It also encourages a shared sense of responsibility and helps products adapt to diverse repair needs.

Manufacturers can support repair efforts by being transparent about their design choices, materials, and components. This openness fosters trust among users and enables third parties to create innovative repair solutions. By sharing information about the composition of materials or the specifications of components, manufacturers can help produce tailored repair strategies, ultimately improving the product's overall repairability.

Repair Communities

Design teams should engage with repair communities to support the repairability of their solutions. It is recommended to consult independent repair shops, organisations advocating for the right to repair, and product service centres. By interacting with repair centres, designers can gain valuable insights into facilitating repair in their product solutions.

Designers should focus on repairability and educate consumers about their right to repair. This education can be included in the product design, packaging, and user manual. They should also make repair manuals and 3D files available to facilitate repair.

Case Study:
Fairphone

Fairphone is a Dutch company that promotes sustainable and ethical practices in product design, focusing on the Right to Repair. They make modular smartphones that aim to prolong the device's lifespan by aiding repairability. The devices are designed to be easily repairable, with replaceable components such as cameras, batteries, and screens. Other brands like Nokia Global have also started adopting a similar approach.

The company provides spare parts for its products, even those no longer manufactured. They also offer repair guides and tutorials on their website to encourage users to perform repairs themselves, reducing the need for professional assistance.

Fairphone values user input for new product development and collaborates with its community to meet product needs. The company's transparent supply chain practices provide consumers with detailed information on material sourcing, labour, and environmental impact. [10]

Links to other content in the Book:

Design for Sustainability - pg.39
Open Design - pg.93
The Imperative of Responsibilty - pg.175

References and Further Reading:

[10.] Case study - Fairphone. . . | Circular Tech. (n.d.). https://circulartech.apc.org/books/a-guide-to-the-circular-economy-of-digital-devices/page/case-study-fairphone-building-a-mobile-phone-that-is-socially-and-environmentally-responsible-and-lasts-longer

The Three R's

Class 4 - The Right to Repair

Worksheet 1

Repair Testing

1. Find a product that you own and analyse it with regards to how easy and accesible it is to repair.

Photograph of a product you own

How easy what is to find repair information?

0 5 10

Who published the repair information?

- [ ] Manufacturer
- [ ] Reputable third party
- [ ] Repair Advocate
- [ ] Other

How was the information presented

- [ ] Printed Document
- [ ] Online Repair Guide
- [ ] Video Tutorial
- [ ] Other

2. What do you need to repair this product? Does it require any special tools or skills? Where can you get spare parts and are they accesible?

What tools do you need to repair this product? Are they common or specialised?

Are the spare parts easy to obtain? Are they generic or proprietary?

Reflect on the what you have learned, how confident are you repairing this item?

Download Worksheet from DOI: 10.5281/zenodo.14621500

Class Activities

The following activities should occur during or after the class to allow learners to apply their knowledge of Repairability in low-tech products.

1. Ask the students to consider some of their own products and research repair documentation for their object. Students should analyse their findings and discuss the following:

- How easy was the information to obtain?
- Whether the manufacturer, a repair partner or the community supported the information.
- The accessibility of the tools and materials required for general repair tasks.
- How confident would the student be to undertake a repair task with their product?

Have students suggest improvements to improve repairability for their item.

2. Assignment Task
For student's redesign project.

Ask each student to redesign the product to enhance its reliability while keeping the design as low-tech as possible. Students should document their reliability interventions in their design portfolio.

Figure 1: An example of the format a function diagram takes

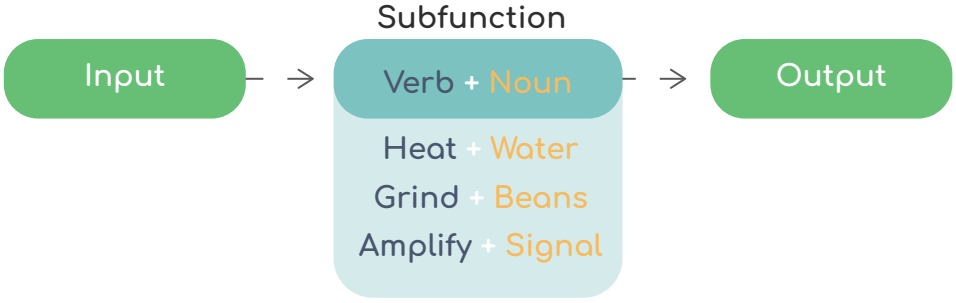

Figure 2: An example of the format a function tree takes

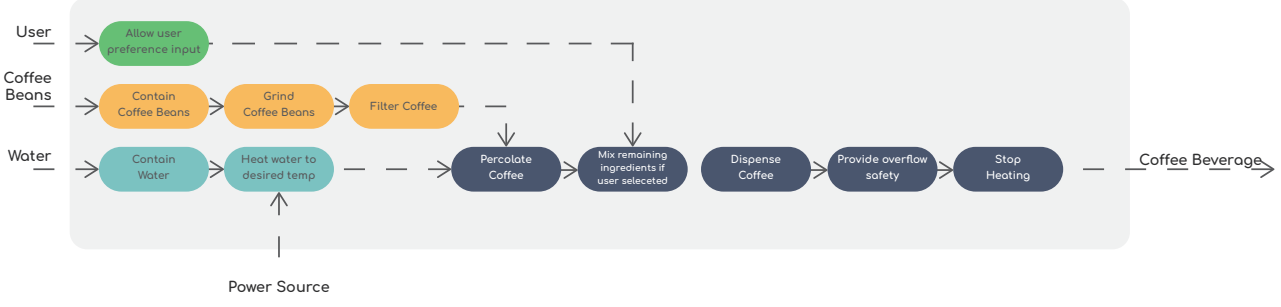

Figure 3: A Function Structure. Engineering Design Process - Y Haik ISBN: 9780495668145 (2011)

5: Taking a systems approach

How to understand the system to develop a resilient approach

What makes for a resilient design?

Designing for resilience means creating solutions that can endure and adapt to challenges and changes. Resilient designs can recover from adverse use, maintain functionality, and continue providing value even in unexpected use cases. In this lesson on resilient design, we will cover several topics, but it is essential for the designer to consider the following from the outset:

- user-centeredness,
- flexibility,
- robustness of materials.

To make a successful solution, designers need to understand the needs of their users and incorporate feedback throughout the design process. A design that meets the user's needs is much more likely to be embraced and maintained, even when demands change. It is essential that designs are flexible and can adapt to different scenarios. To achieve this, incorporating adjustable features can be helpful. It is also necessary to understand the boundaries of use for the product.

When designing products, it is crucial to consider the technical limitations of material choices. Choosing high-quality, durable materials that can withstand wear and tear and environmental factors is necessary to ensure longevity and prevent premature failure. Additionally, designers should consider material choices' social and emotional aspects to maintain user attraction even after heavy use.

Finally, designers must adopt a systems thinking approach to create compelling designs. This means understanding how different components and interactions contribute to the system's performance.

Functional Analysis

Performing a function analysis is one of the simplest ways to gain a complete understanding of a design solution. This analytical tool breaks down the product into its components to create an abstract model of its functionality. The primary objective is to understand the relationship between functions and components. By identifying and comprehending the specific tasks or goals that a product is intended to accomplish, the designer can justify the essential functions, thus enabling greater clarity in the development of the system.

Function diagrams, function trees, and function structures are tools that designers employ to analyse, organise, and systematically optimise a product's functions. These methods help designers ensure the product solution is well-structured, logically sequenced, and optimised for efficiency and functionality.

Function Diagrams:

Function diagrams are visual representations that show how different system functions are connected. Designers use them to understand how the various parts of a product work together to achieve the overall function. These diagrams help identify how distinct functions depend on each other and the order in which they must operate. This allows designers to plan the design tasks logically. With function diagrams, designers can see how changes in one function impact others and will enable them to adjust their designs accordingly. This makes analysis of the effects of modifications and improvements to the design easy.

Function Trees:

Function trees provide a hierarchical breakdown of functions, starting from the primary function and branching out into sub-functions. Function trees are used to organise and categorise the system functions, creating a clear structure for the design process. Function trees help designers identify essential functions for the product's core purpose. By focusing on these critical functions, the design team can ensure that the product's core functionality is resilient and well-designed.

Function Structures:

Function structures are diagrams that provide an in-depth understanding of how functions, inputs, processes, and outputs relate. Designers use these diagrams to identify parameters, constraints, and potential improvements in each function, helping them seamlessly integrate different system components.

By understanding the interdependence between functions, designers can create cohesive interfaces and part assemblies, leading to a more usable and robust design. Function structures can also optimise the design by allowing designers to analyse the system and its sub-functions for efficiency and effectiveness. This helps identify opportunities for improvement and refine the product solution.

Using Function Trees in conjunction with Function Structures allows designers to manage their time more efficiently by identifying tasks requiring greater attention, resources, or innovation. This approach enables designers to prioritise their efforts based on the criticality of functions in the tree, which ultimately leads to more effective design outcomes.

Potential disruptions must be considered when designing a product. Therefore, it is crucial to analyse internal and external factors that could cause system failures. An adaptive system should be able to continue functioning even with environmental changes.[11]

Links to other content in the Book:
Effectiveness, Efficiency, Sobriety pg.147

References and Further Reading:

[11.] Colton, K., & Almrott, C. (2023, September). Product Function and Failure [Slide show; DGMM 3411 Design & Manufacturing Methods].

Above: GD Stream. Cross-government Design Systems Meetup at GDS. December 2017. GD Stream Flickr Account. https://flic.kr/p/Fcu8Zb

Diversifying the components used in the product to minimise the risks of failure is recommended. Depending on a single component can cause problems if it fails, so using diversified components or FMEA can significantly reduce the risk.

A modular component design is suggested to reduce the maintenance load and the possibility of the system failing due to a single point of failure. This design enables easy identification and replacement of the component, reducing downtime and increasing the system's longevity.

Failure Mode and Effects Analysis

Designers should evaluate potential vulnerabilities and their impact to identify risks. This helps prioritise and reduce risks based on severity. FMEA is a systematic approach to preventing product and process problems, enhancing safety, and increasing customer satisfaction.

It is recommended that FMEAs be conducted during the product design or process development stages. However, conducting an FMEA on existing products and processes can also provide significant benefits.

When conducting an FMEA, the relative risk of a failure and its effects is determined by three factors:

- Severity:
  The consequence of the failure should it occur.
- Occurrence:
  The probability or frequency of the failure occurring.
- Detection:
  The probability of the failure being detected before occurring.

Each Failure Mode is rated out of 10 for the three factors. Multiplying these (severity × occurrence × detection) creates a risk priority number (RPN) that will be determined for each potential failure mode and its effect.

The Risk Priority Number (RPN), which can range from 1 to 1000, is a metric used to assess the need for corrective actions to eliminate or reduce potential failure modes. With the help of this analysis method, designers can prioritise areas of their system that need immediate attention and take a systematic approach to enhance safety and resilience within their solution.

Designers can develop resilient solutions by applying systems thinking and considering strategies to withstand disruptions and continue providing value to stakeholders.

References and Further Reading:
[12.] Practical Action, 2022. The 6 R's. [Online].
Available at: https://practicalaction.org/the-6-rs

Above: Ceri Almrott. Student at a low-tech hackathon considering their system. April 2024. TU Dublin.

Class Activities

The following activities should occur during or after the class to allow learners to apply their knowledge of Repairability in low-tech products.

1. Assignment Task
For student's redesign project.

Ask each student to consider their product. Ask them to construct the following diagrams to explain the system:

- Function Diagram
- Function Tree
- Function Structure

Ask the student to consider the functional design of their product and suggest less technologically intensive ways of producing the same outputs. These should be explained through an updated function structure diagram.

2. Hackathon Task
For student's redesign project.

Students should consider their low-tech solution and analyse the design within the functional frameworks presented. Students should be able to use the Function Diagram, Tree and Structure for their solution.

Above: Dan Edwards. Cooking While Camping. October 2015. Unsplash. https://unsplash.com/photos/meat-and-vegetable-on-cooking-pan-KwnMOxpHLE4

6: Emotionally Durable Design

Emotionally durable design is an approach that focuses on creating long-lasting emotional connections and meaningful experiences for users through products. Instead of following short-lived trends or relying on disposability, designers who engage in emotionally durable design aim to produce products that endure changing fashions and continue to evoke positive emotions and attachments over time. This approach involves considering the relationship between users and the product, the product's ability to age gracefully, and the emotional impact of design choices. By promoting long-lasting bonds between users and their possessions, emotionally durable design encourages sustainable consumption patterns, reduces waste, and fosters a more meaningful and sustainable consumer culture.[14]

Connecting with Users

Emotionally durable design creates products that connect with users on a deeper emotional level. By understanding their psychological needs, designers can create products that resonate with users, leading to stronger connections, long-lasting relationships, and greater satisfaction. User research should be done within the users' cultural context. This will help designers create products that align with users' cultural identity and values.

Craft and Material

Product designers should anticipate future needs in terms of aesthetics. Designs should have timeless appeal and remain relevant for decades. The module The Art of Simplicity discusses this concept. Certain principles and approaches can help achieve a timeless aesthetic:

Simplicity and Minimalism:

Simplicity and minimalism in designs create a timeless quality as they age gracefully and stay relevant to users. Simple designs are adaptable and versatile, seamlessly integrating into different environments and styles and complementing diverse interiors or fashion styles.

Balanced Proportions:

Well-balanced proportions create a visual sense of harmony and stability by paying meticulous attention to the distribution of elements.

Attention to Detail:

Meticulous attention to detail, such as carefully crafted joints, exquisite finishes, or fine stitching, distinguishes design work. These precise details enhance aesthetics and contribute to enduring feelings of quality.

High-quality materials and expert craftsmanship are vital to creating designs that deeply resonate with users, fostering lasting connections between people and their belongings. Quality materials like solid wood, genuine leather, or fine metals convey luxury and authenticity. They increase the perceived value of a product, building trust and satisfaction and ultimately strengthening the emotional bond between user and product. High-quality materials are often more durable and develop a unique character over time. This encourages their use through multiple generations, reinforcing strong emotional connections between the user and the object.

High degrees of craftsmanship enhance the tactile and visual experience of the product. Smooth finishes, precise joinery, and attention to detail create a sensory delight for users. When users touch, feel, or even smell the quality materials, it triggers positive sensory responses, developing a sense of pleasure and emotional attachment. Craftsmanship, when executed with precision and artistry, transforms products into works of art. Users appreciate the skill and dedication invested in creating each piece. This artistic expression resonates deeply, eliciting admiration and emotional resonance. Users often form an emotional bond with products that testify to exceptional craftsmanship.

High-quality products often come with a rich narrative highlighting the expertise of the artisans who made them and the heritage of their craft. This emotional narrative adds life to the object, giving users a sense of connection to its origin and the traditions it represents. When users own a well-crafted product, they often feel a unique sense of pride and appreciation for it and perceive the product as an extension of their identity – important to enhancing their emotional attachment.

Narrative and emotional engagement

Good design depends on compelling storytelling. Stories add depth, context, and personal connection to products, creating emotional resonance with users. By conveying the inspiration, purpose, and values behind their products, designers help users develop strong personal attachments to them – if they get the story right. Stories that align with a user's beliefs, values, or experiences generate a personal connection with a product, likely fostering emotional attachment. When a product's story resonates with a particular group, it fosters this sense of belonging. People feel included in a community that appreciates the same narrative, strengthening their emotional attachment to the product.

References and Further Reading:

[13.] Chapman, J. (2005). Emotionally durable design: Objects, Experiences and Empathy. Routledge.

The Three R's

Class 6 - Emotionally Durable Design

Worksheet 1

Heirlooms

1. Find an object you own that has been passed down to you. Ideally your object is something that has been passed down through two previous generations of your family.

Photograph of heirloom product

What is the object and what does it do?

2. Reflect on the item. What is it's narrative? How did you come to own it, who owned it before you. Where did it come from and how has it featured in the story of your family.

What is the story of this item?

3. Reflect further: what is it about this item that gives it longeveity, what makes it emotionally durable? Are your feelings about it the same as those of other generations of your family?

What makes this item an heirloom to you?

Download Worksheet from DOI: 10.5281/zenodo.14621500

6: Emotionally Durable Design

Case Study:

Le Creuset Cookware

Le Creuset is a French cookware manufacturer that has been around since 1925. The company is famous for its iconic enamelled cast iron cookware, which has a special place in the hearts of its users. People tend to form an emotional connection with their cookware because they look forward to creating cherished meals and memories with it. As the cookware ages, it retains its functional integrity and gains sentimental value, which fosters a long-lasting relationship between the user and the product.

Le Creuset's dedication to ensuring their products remain durable aligns with the principles discussed earlier in this module. The availability of replacement parts and the company's commitment to extending its lifespan enhance Le Creuset cookware's emotional resilience. As a result, users feel satisfied with maintaining and repairing their cookware, which contributes to its emotional durability.

Le Creuset cookware is known for its classic, timeless design and vibrant use of coloured enamels. The aesthetic appeal of the cookware creates an emotional connection, as the design is not tied to any particular trend but aligns effortlessly with many enduring culinary traditions. When given proper care, the enamel finish on Le Creuset cookware matures and develops a unique patina. This personalisation over time adds an extra layer of emotional value as each scratch, and mark tells a story of countless shared meals and culinary experiences.

Le Creuset's cookware design language produces versatile objects that easily transition from stove to table. This feature is practical for users and helps establish a lasting relationship with the cookware as it becomes an essential part of their cooking and dining routine. While Le Creuset cookware may have a high initial investment cost, its long-lasting material choices and significance in countless family meals make them a valuable item often passed down through generations or highly sought after in second-hand stores.

Class Activities

The following activities should take place during or after the class to allow learners to apply their knowledge of system design in low-tech products.

1. Ask students to identify an object they own that has been passed on to them through at least three generations (Parent or Guardian/Grandparent).

Students should discuss the object and write a short reflective piece on the object in which they analyse the narrative held within the object. Students should consider what it is about the object which has made it emotionally durable across multiple generations.

2. Assignment Task

For student's redesign project.

Students should assess the design of the object through the lens of emotionally durable design. They should describe and analyse the object in terms of its emotional durability and suggest alterations to the design, which will increase its likelihood of maintaining an emotional connection with users now and in the future.

Above: Advertisment for Fiskars Scissors. 1967. Fiskars..
https://www.fiskars.com/en-us/about/heritage

7: Material Choices

and their role in reliable and resilient design solutions

Before the Industrial Revolution, an area's geography significantly influenced the manufacturing of objects. The success of a product and the choice of materials used in its production were heavily reliant on the available material resources of the region where it was made. However, in the modern era, we have developed various innovative and intricate materials, resulting in a greater diversity of materials available to designers than at any other point in human history.

Selecting suitable materials is critical to creating reliable and durable product designs. Choosing the best materials can improve a product's performance by increasing its strength, endurance, and resistance to environmental factors. Designers should work with experts and conduct extensive research, testing, and simulations to make informed material choices. Keeping up to date with emerging materials and technologies is also crucial. Designers need to consider the intended lifecycle of a product, potential stressors it may encounter, and end-of-life disposal methods when making decisions about material selection. By taking a systematic approach and staying informed, designers can improve the resilience of their designs and create products that perform reliably over time.

Material Characteristics

To create an effective design solution, it is imperative to understand the characteristics of the materials we use. We must consider our design's technical and emotional aspects and carefully weigh them against each other during the material selection. When choosing materials, it's also essential to consider their reliability, considering several significant material characteristics.

Durability

Durability is a critical factor in selecting materials for reliable products. This characteristic refers to a material's ability to withstand wear, environmental stressors, and ageing. Durable materials enhance a product's lifespan through greater structural integrity, reducing the risk of failures and ensuring that a product maintains relevant, safe operating conditions.

Toughness

Toughness is a material's ability to absorb energy and deform plastically without fracturing under stress, absorbing energy in the process. It's crucial for reliability and durability, especially for components exposed to unpredictable forces. Tough materials exhibit resilience and reduce the likelihood of catastrophic failure.

Ductility

Ductile materials can withstand deformation without fracturing, making them ideal for products exposed to stress. They resist sudden failure and are more resilient to impacts and bending. This is important for components subjected to dynamic forces, ensuring product reliability and safety. Ductility prevents sudden failures and promotes long-term structural integrity.

Maintenance

Regular maintenance is crucial for materials, not just mechanical systems, to maintain performance. Environmental factors such as light, heat, and moisture can degrade materials, compromising integrity. Mitigating these factors through design or protective measures, such as varnishes, conditioning oils, or coating, ensures prolonged resilience across various applications.

Material Selection

As designers, we must consider various factors regarding material choices beyond just cost implications. In Class 3 - Strategies for Designing Reliable Low-Tech Solutions, we learned that local availability is important in making decisions. Using local resources, like those used by EC Emmerich, can help shape dependable products, reducing reliance on complex logistics.

Apart from local availability, we must also consider the product narrative. It's essential to align material choices with emotional and technical needs. The materials used should gracefully reflect the product's value, production process, and age to maintain emotional appeal. Ultimately, our selections should harmonise with the product narrative, ensuring coherence and longevity in design.

Case Study:

Fiskars Scissors

Fiskars is a well-known Finnish company that has gained worldwide recognition for its iconic orange-handled scissors. Introduced initially as fabric scissors in the late 1960s, the scissors are designed with two materials: stainless steel for the blades and distinctive orange plastic for the handles. The use of stainless steel wasn't groundbreaking, but it did ensure that the scissors had hard, sharp cutting blades that could continue to cut smoothly through fabric and other materials without leaving any marks. Designer Olof Bäckström's decision to use plastic for the handle of scissors was a revolutionary move. This allowed for more complex and ergonomic forms that could be easily manufactured from the all-metal designs of that time. The material was also impact-resistant and lighter in weight, which meant the scissors could be used comfortably for longer periods and were less likely to be damaged if accidentally dropped.

Bäckström understood the significance of ergonomics in his scissor design and ensured that left- and right-handed people could use its handle comfortably. During the production of the prototypes, the injection moulding machine used orange plastic to create an orange juicer, and the bright colour was fashionable then. The designers decided to stick with the orange colour, which became Fiskars' iconic colourway. The distinctiveness and brightness of the orange colour made it easier for the users to identify and use the scissors, adding to their emotional durability.

References and Further Reading:

[14.] Weller, C. (2017, September 28). These perfectly-designed orange scissors are iconic — take a look at their history. Business Insider. https://www.businessinsider.com/history-of-iconic-fiskars-orange-scissors-2017-9

Above: Andrea Piacquadio Shallow Focus Photo of Woman Sitting on Chair While Smiling. May 2018. Pexels. https://www.pexels.com/photo/shallow-focus-photo-of-woman-sitting-on-chair-while-smiling-3801402/

Class Activities

The following activities should occur during or after the class to allow learners to apply their knowledge of Repairability in low-tech products.

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Ask the student to consider the functional design of their product and suggest less technologically intensive ways of producing the same outputs. These should be explained through an updated function structure diagram.

2. Hackathon Task
For student's redesign project.

Students should consider their low-tech solution and analyse the design within the functional frameworks presented. Students should be able to use the Function Diagram, Tree and Structure for their solution.

Effectiveness, Efficiency, Sufficiency

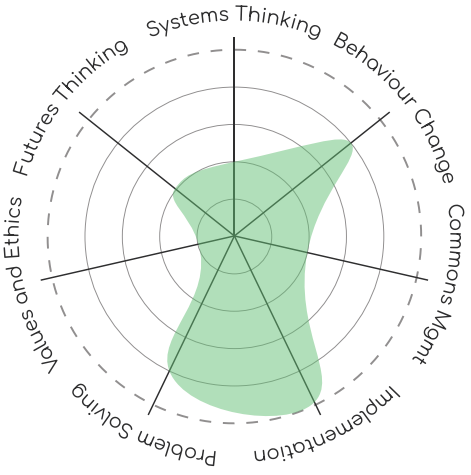
Trade-offs between design objectives

Benoit Delinchant, Philippe Fortemps & Sacha Hodencq

3 lessons
3 Self-directed Student Assignments

Above: This is Engineering. Engineers discuss designs in front of whiteboard. June 2019. Flickr. https://www.flickr.com/photos/thisisengineering/48676669273/in/album-72157711373118421/

The Trade-offs between design objectives



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	User centredness, Qualitative and Quantitative analysis, decision aiding	8
Case Studies	Explore and analyse case studies around transportation using the above framing	3
Blind Kahoot	Understand the difference between effectiveness, efficiency and sufficiency	1
Self-Directed	Sustainability practices and case study analysis. Preparation for a hackathon on low-tech	12

Module Objectives

This course intends to equip engineering students with high knowledge for low-tech design. The knowledge and skills necessary for effective decision support address simultaneously 3 specific criteria: effectiveness, efficiency and sufficiency.

The curriculum encompasses various essential concepts, including the systemic approach featuring complexity and uncertainties, and will focus on multicriteria decision making. Students will delve into the realms of multi-criteria preference modeling to develop a comprehensive understanding of the factors influencing decision-making in low-tech systems design

Learning Outcomes

Course Goals

Upon completion of the course, students will possess a robust understanding of decision-making processes in low-tech systems design. They will be proficient in applying multiple-criteria decision-making methodologies, with a focus on the practical implementation of the ELECTRE method in real-world scenarios.

Learning Outcomes

Upon completion of the course the learner shall be able to:

- Define and understand interaction between efficiency, effectiveness and sufficiency criteria.
- Define user needs and satisfaction levels
- Conduct a critical evaluation based on qualitative and/or quantitative criteria
- Understand and experiment with the strategies to improve criteria

Above: Mathew Schwartz. three brown windmill on crop field. October 2017. Unsplash. https://unsplash.com/photos/three-brown-windmill-on-crop-field-Jwj1KiuX42c

1: Effectiveness, efficiency, and sufficiency

Introduction

The Low-Tech approach emphasises the need for various changes: Technical with resource savings and the increase of devices' lifespan; Social with appropriation, matching the local needs; and Organisational with context dependency, resilience and collaboration (Tanguy, Carrière, et Laforest 2023). When it comes to technical systems and components, these changes can be embodied with three complementary principles: efficiency, effectiveness and sufficiency.

Efficiency definition

A common principle to decrease a device's consumption is improving efficiency. Efficiency is about minimising the resource consumption for a given service. It questions the adequacy of the effects obtained compared to the means mobilised and whether the same results could have been achieved at a lower cost or impact. Efficiency is often measured as the ratio of useful output to total input: efficiency=P/ C
with P the amount of useful output ("product")
and C the amount of resources input ("cost").

Efficiency example:
Improving the efficiency of a motor for cars
This definition can be widened through a systemic view if we include other « costs », such as emissions and wastes, and will depend on the boundaries of the considered system (see 2. An Introduction to systemic approach). See Figure 1, with technosphere resources (e.g. human labour, time, money) and ecosphere resources (e.g. raw material, energy).

Efficiency and optimality

Productive efficiency means we can produce the given output at a lower cost or more output for a given cost. Then efficiency is trying to be optimal. The danger of optimisation is that it is always at the expense of other indicators: everything not included in the cost function will be removed.
Dealing with optimality needs to add some other concepts:

- Problem formulation: don't forget implicit or tacit knowledge
- Adding constraints: to avoid going beyond some criteria
- Multi-criteria optimisation: including criteria in the cost function. Then dealing with balancing the importance between each objectives.

Efficiency and rebound effect

Efficiency also faces a systemic effect called the rebound effect or take-back effect. It has been known since the Industrial Revolution when there was an increase in coal consumption (Jevons' paradox). In a forced growth system, efficiency gains translate into increased global use. The rebound effect can be:

- Direct, with an opportunity effect (the cost decrease, increasing the use of the service) and a substitution effect (the resources saved are used to increase the service),
- Or indirect (the gas savings compensate for another pollutant transportation mean)[1]

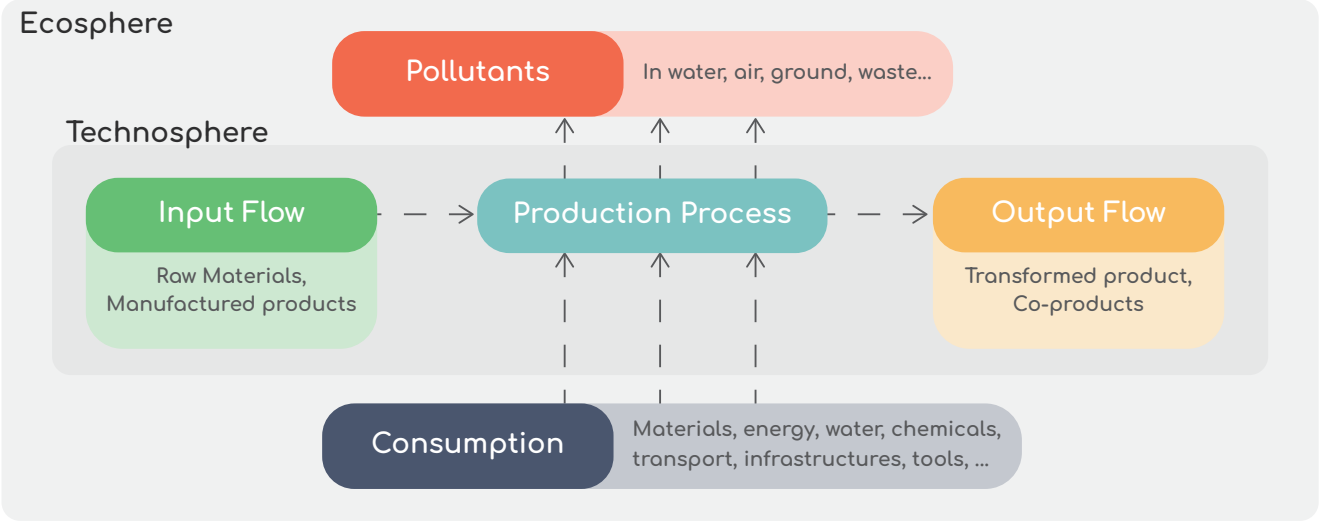


Figure 1: System view of product production

References and Further Reading:
[1.] Pierre-Yves Longaretti, "Sobriété et effet rebond Enjeux, obstacles, leviers", Labos 1point5 - Janvier 2023 https://labos1point5.org/les-seminaires/hiver-2023

Above: Felix Mizioznikov. Aerial image of the I10 Katy Tollway Houston Texas. July 2018. Adobe Stock. https://stock.adobe.com/ie/images/aerial-image-of-the-i10-katy-tollway-houston-texas/218781663?asset_id=218781663

Rebound effect examples:

- The motors in cars are becoming more and more efficient. Still, the overall fuel consumption of cars does not decrease accordingly due to the increase in the size of the vehicles. A one per cent fuel economy increase raises driving by 0.2 to 0.4 per cent [2]
- Another emblematic example is digital devices. With a more efficient 5G cellular network, more and more people are watching videos/films on public transport. The digital sector's overall material and energy consumption is rising exponentially, reaching more than 1% of the world's electricity consumption in 2014 (IEA 2017).

Effectiveness definition

The best possible efficiency can also be useless if it doesn't meet real needs. Effectiveness tackles this limitation by considering the ability of a product to be helpful in a given context for given objectives rather than a (difficult to reach) context-free overall efficiency. Effectiveness (or effectivity) is the degree to which something achieves its goals or produces the desired results. It focuses on the outcome or impact of a product or a process. Effectiveness is often measured by how well an objective is accomplished or how successfully a particular approach achieves the desired outcome. Effectiveness calls for a user-centred approach in design methods, as poorly defined objectives will ultimately lead to lower effectiveness.

Methods are based on researching customer and/or user needs. The objective is to listen and observe, to empathise. Empathise means putting oneself in the audience's position to understand their wants and needs better. Popular methods include surveys, focus groups, interviews, and keyword research. Sometimes, you'll discover new problems; other times, you'll investigate known ones. A possible resource can be design thinking methodology[3]

Effectiveness example:

Instead of enlarging an existing road to absorb the increasing number of cars in a city, it could be more effective to define the mobility plan in the town with the inhabitants, based on their needs and practices.

For instance, the Katy Freeway in Houston, Texas, demonstrates the limitations of conventional approaches to congestion management. Despite being expanded to 26 lanes, the freeway has failed to resolve traffic congestion due to the phenomenon of induced traffic—where increasing road capacity encourages more vehicle use, ultimately exacerbating the problem. (See Image Left)

Sufficiency definition

Besides effectiveness, we must question and prioritise things. Sufficiency emphasises meeting the minimum or necessary level without excessive or unnecessary abundance. It is derived from the Greek word "sôphrosunè," which was translated in Latin to "sobrietas" in a sense of "enough". In sustainability, sufficiency often relates to consuming or using resources in a balanced way that does not exceed the Earth's capacity.

Parallels are often drawn between the Low-Tech approach and sufficiency, as the Low-Tech approach seeks to question the needs and decrease consumption. They also share the same types of locks, such as desirability and social acceptability facing mainstream models, the necessary involvement of citizens, the need to offer a common culture and actual views of the alternative, as well as administrative and financial locks to disseminate (Bonjean et al. 2022).

Sufficiency can be differentiated between structural sufficiency (offering the proper conditions for consumption decrease), sizing sufficiency (proper sizing of equipment compared to the actual use), use sufficiency (reducing the use of equipment), and convivial sufficiency (sharing and commons mechanisms).

Sufficiency IPCC WP3 definition[4] (Yamina Saheb's work) is avoiding the demand for materials, energy, land, water, and other natural resources while delivering a decent living standard for all within the planetary boundaries

Among all consumption sectors where sufficiency can be applied, energy sufficiency has been identified as a lever of choice for reducing the socio-ecological impacts of the energy sector in addition to other levers (development of renewable energy to replace carbon-based energy and energy efficiency), particularly in developed countries (Ivanova et al. 2020). While the contribution of sufficiency to the energy transition has so far rarely been explored in relation to the use of technology alone (Samadi et al. 2017), it is beginning to appear in reference scenarios with the explicit mention of "sufficiency" policies in the IPCC report in 2022 (Shukla et al. 2022). In 1999, Wolfgang Sachs introduced sufficiency with the following terms: "While efficiency is about doing things right, sufficiency is about doing the right things" (Sachs 1999). Energy sufficiency can be defined as reducing energy demand sustainably without falling below people's basic needs (Bierwirth et Thomas, 2019). As a result, it also brings about energy justice considerations, both in terms of distribution: sufficiency particularly concerns big consumers who are far from energy poverty, and in terms of recognition and procedure, as sufficiency is not only thought of individually, but is instead a matter of collective decision, and so, of democracy. For instance, we can ask ourselves: what are we attached to? What could we give up? Or, what is sufficient for us to flourish in a constrained world? So when it is clear we ask ourselves why, what, and how to produce, it is equally important to reflect on who asks these questions and who answers them (Mateus et Roussilhe, 2023). As such, sufficiency should not be reduced to "eco-friendly little acts" and must be studied long-term at a societal scale.

Sufficiency examples:

Decreasing the temperature in buildings at 19°C and heating bodies through clothes and other techniques rather than buildings only. Also, it is important to ensure that everyone has their say in this decision and that households can heat up to 19°C.

References and Further Reading:

[2.] Linn, Joshua. "The Rebound Effect for Passenger Vehicles." The Energy Journal, vol. 37, no. 2, 2016, pp. 257–88. JSTOR, http://www.jstor.org/stable/24696756

[3.] Design thinking, explained | MIT Sloan. (2017, September 14). MIT Sloan. https://mitsloan.mit.edu/ideas-made-to-matter/design-thinking-explained

[4.] Climate Change 2022: Mitigation of climate change. (n.d.). IPCC. https://www.ipcc.ch/report/ar6/wg3/

Above: Luke Stackpoole. the sun shines through the trees in a forest. May 2018. Unsplash. https://unsplash.com/photos/the-sun-shines-through-the-trees-in-a-forest-ke50GMONqqo

2: Design as a Complex Activity

The aim is to study multi-criteria decision support while designing low-tech systems. Before doing so, it is necessary to introduce various concepts, such as the systems approach and complexity. The module doesn't go into system modelling but tries to highlight the existence of interaction effects and identify most of the consequences of creating a new product. Designing simple solutions (low-tech) doesn't mean considering simple challenges.

Introduction to complexity

"When I talk about complexity, I'm referring to the basic Latin meaning of the word "complexus", "that which is woven together". The components are different, but we need to see the overall picture, as in a tapestry. The real problem (in terms of thought reform) is that we have learned too well to separate. It's better to learn to connect. Linking, that is to say, not just making an end-to-end connection, but making a looping connection. [...] Today, knowledge must have the tools, the fundamental concepts that will enable it to be linked. fundamental concepts that will enable us to make connections."
Edgar Morin, 1995.[5]

Edgar Morin introduces complex thinking as the union between:

- Critical thinking: guided by specific criteria, procedural, self-correcting and context-sensitive.
- Creative thinking: guided by sometimes contradictory criteria, heuristic, more results-oriented, self-transcending (synthetic), governed by the context in which it appears.
- Responsible thinking: presupposes dialogical communication (i.e. the construction of a coherent set of complementary, competing or antagonistic proposals to represent a phenomenon), openness to others and differences, and a willingness to change.

We are facing social and ecological crises that can easily be considered to be complex issues, that is to say, issues with:

- Mutually influencing variables,
- A context of great uncertainty,
- Multiple players with divergent value systems

Relevant approaches, such as system thinking and indicators, must be used to address such issues. It needs to be underlined that Science can appear to be ineffective for decision-making in situations of conflict of interest (Pielke 2007), so decision-making approaches need to be accompanied by governance tools in order to be effective in facing complexity (the commons presented in the Open Design module are examples of such governance tools).

Introduction to a systemic approach

Understanding the fundamental principles of the systemic approach for addressing interleaved multifaceted challenges.

"A system is an interconnected set of elements that is coherently organised around some purpose"
(de Vries 2013).

System thinking aims to distance itself from discrete events and move beyond reactive decision-making based on patterns and behaviour to generative decision-making (George Richardson 2013). It focuses on policy structure and identifies causality, providing insights into how a system works. The system perspective requires a deep understanding of causality and how system elements interact; it is an inherently interdisciplinary approach.

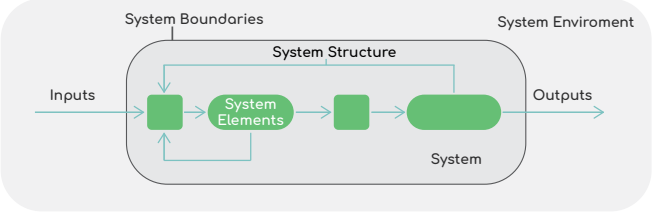


Figure 2: System diagram. Source: Hugo Leboulzec from Bossel 1994

System approach features four key considerations (George Richardson, 2013):

- Dynamic thinking (graphs over time)
- Causal thinking (cause/effect relationship, see next paragraph)
- Stock-and-flow thinking (accumulation)
- Thinking endogenously, i.e. with the internal cause or origin of a behaviour.

References and Further Reading:

[5.] Morin, E. (1995). La stratégie de reliance pour l'intelligence de la complexité. Revue Internationale De Sytémique, 9(2), 105–112. http://www.res-systemica.org/ris/vol-09/vol09-num-02/ris-vol09-num02-p105-112.pdf

“There is a maxim which is often quoted, that ‘The same causes will always produce the same effects.’ To make this maxim intelligible we must define what we mean by the same causes and the same effects, since it is manifest that no event ever happens more that once, so that the causes and effects cannot be the same in all respects.”

James C Maxwell
“Matter and Motion”, 1876

Introduction to Causal Thinking

Causal thinking deepens the understanding of the system's behaviour. It is different from correlation, which is a mutual relationship or connection between two or more things that only replicates past behaviour based on historical analysis. Causation mimics actual behaviour, which can change over time: it represents the system's structure.

Causal thinking enables the representation of causal loop diagrams, i.e., "variables connected by arrows denoting the causal influences among the variables" (Sterman, 2000), with positive (if the cause increases → the effect increases and vice versa) and negative (if the cause increases → the effect decreases and vice versa) directions.

These polarities give way to reinforcing causal loops (an action produces a result that influences more of the same action, thus resulting in growth or decline) or balancing causal loops (circles of cause and effect that counter a change with a push in the opposite direction)—see Figure 3.

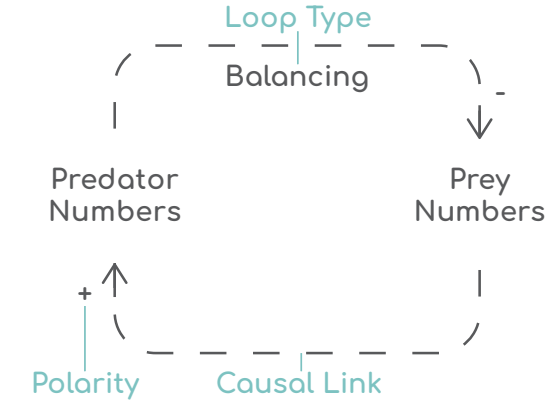


Figure 3: Causal loop diagram. Source: Hugo Leboulzec, 2023

Choosing the right indicators

To achieve systemic approach correctly, the boundaries of the studied system need to be clearly defined.

> In concept a feedback system is a closed system. Its dynamic behavior arises within its internal structure. Any action which is essential to the behavior of the mode being investigated must be included inside the system boundary.
> Forrester (1961).

But within these boundaries, many aspects or indicators can be considered or not. In order to face complexity, we are addressing low-tech design with the prism of 3 main criteria: effectiveness, efficiency, and sufficiency. But we could add the 3-R (reliability, reparability, resilience), the art of simplicity or the ethical decision-making for avoiding harm and doing good, looking to justice, autonomy, solidarity... It is important to define a list of criteria we want to look at. [Figure 4].

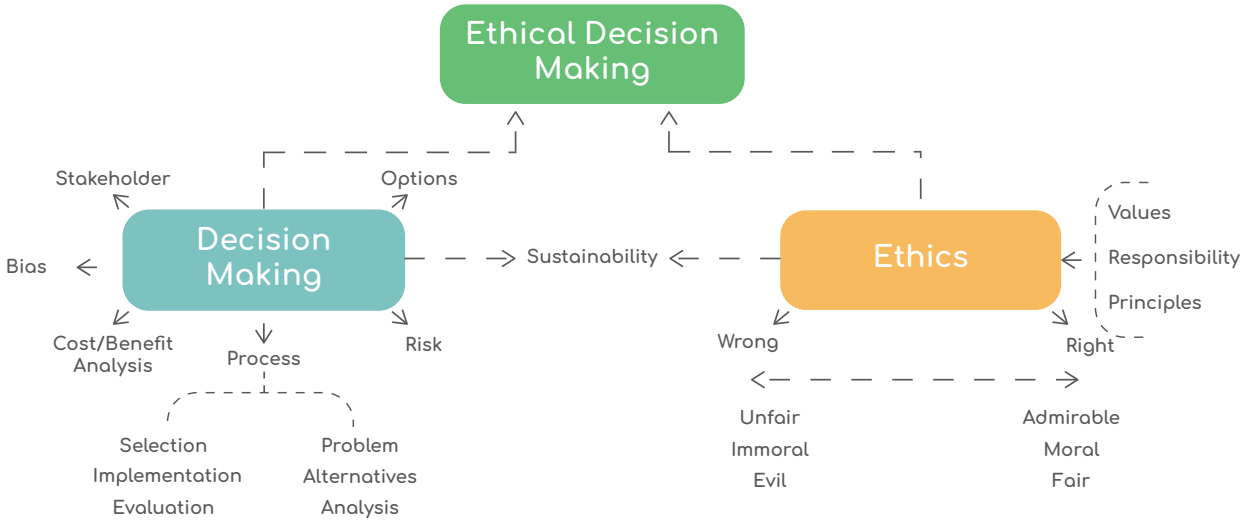


Figure 4: Ethical decision-making - Based on : https://www.collidu.com/presentation-ethical-decision-making

Links to other content in the Book:
The Art of Simplicty (p. 67)
The Three R's (p. 111)
Imperative of Responsibility (p. 177)

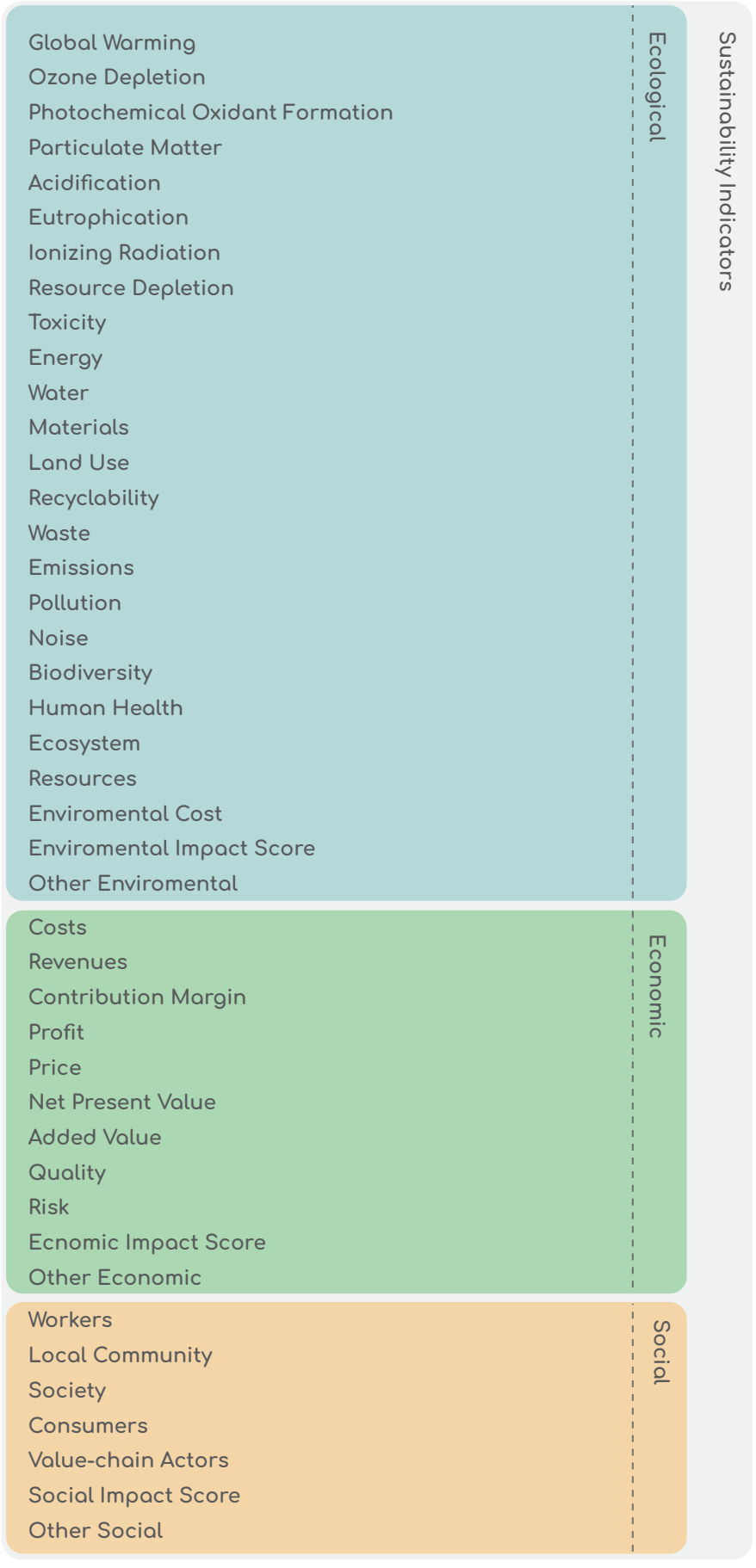


Figure 5: Sustainability Indicators - Thies, C., Kieckhäfer, K., Spengler, T. S., & Sodhi, M. S. (2019). Operations research for sustainability assessment of products: A review. European Journal of Operational Research, 274(1), 1-21.

Structuring criteria is required when dealing with many criteria. For instance, it has been done from literature review on sustainability indicators in [Figure 5].

One can look to many criteria, like [Figure 6] used in the context of transportation infrastructure decision making.

However, in a systemic approach, it is also important to apply the principle of Occam's razor, also known as the principle of simplicity of parsimony. It can be formulated as follows: "The simplest sufficient hypotheses should be preferred". We will see how to quantify which criteria are considered necessary and sufficient using preference modelling.

Figure 6: Indicators for transportation infrastructure decision-making.
Dimitriou, H. T., Ward, E. J., & Dean, M. (2016). Presenting the case for the application of multi-criteria analysis to mega transport infrastructure project appraisal. Research in Transportation Economics, 58, 7-20

Above: Tima Miroshnichenko. People Looking at the Screen if a Laptop Together. February 2021. Unsplash. https://www.pexels.com/photo/people-looking-at-the-screen-if-a-laptop-together-6914429/

Collective or group decision-making

Group decision-making is a more complex process than individual decision-making[6]. It involves deliberation, discussion, and dialogue to build consensus. However, in real-world situations, experts may not have enough knowledge about every alternative or criterion. It's worth noting that each individual's decision can be influenced by the social group. An interesting aspect of group decision-making is empowerment, as engagement is stronger when participating in the decision-making process. Some of the group decision-making methods include decision-making, voting-based methods, Delphi method, and Dotmocracy.

Handling uncertainties and subjectivity

One final aspect of the topic of complexity is the question of uncertainties. How do we handle uncertainties and subjectivity during the decision-making process?

One can distinguish uncertainties in the problem-solving itself, or about the problem setting as described by Padulo et al. in the following figure.

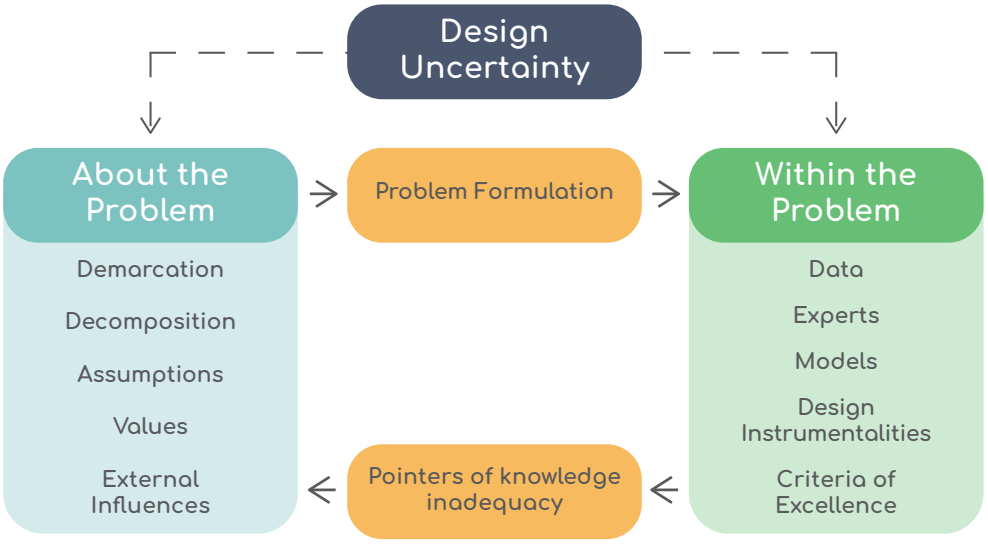


Figure 7: Uncertainties during problem-solving and problem setting

Decision-making deals with vagueness and impreciseness. A framework developed by Pelissari et al [7]. helps with choosing the uncertainty modelling technique according to the type of data uncertainty, whether related to ambiguity, stochasticity, or partial information.

Most of the multi-criteria decision-making literature treats uncertainties based on the following modelling techniques:

- Probabilistic: it has been mostly characterised by stochastic methods, with probability distributions of different shapes assigned to the possible performance data.
- Fuzzy: It allows dealing with the vagueness of information. It specifies a soft transition from one qualitative performance level to another (e.g., from 'poor' to 'fair') without an abrupt change of the degree of possibility.
- Others:
  - evidential reasoning: each performance is represented using a belief structure defined by a distributed assessment
  - gray numbers (interval): performances are specified by clear boundaries without indicating an exact position of the performance within these boundaries.

Beyond modeling techniques, post-normal science is a problem-solving strategy when facts are uncertain, values are contested, stakes are high, and decisions are urgent. It can be formulated as a call for the democratisation of expertise and is considered as a movement for informed critical resistance.

References and Further Reading:

[6.] Wikipedia contributors. (2024, May 23). Group decision-making. Wikipedia. https://en.wikipedia.org/wiki/Group_decision-making

[7.] Pelissari R, Oliveira MC, Abackerli AJ, Ben-Amor S, Assumpção MRP. Techniques to model uncertain input data of multi-criteria decision-making problems: a literature review. International Transactions in Operational Research; 2018. doi: 10.1111/itor.12598

“the ability of the designer to recognise as many of the constraints as possible; his willingness and enthusiasm for working within these constraints. The constraints of price, of size, of strength, of balance, of surface, of time, etc.; each problem has its own peculiar list.”

Charles Eames
from Design Q&A, 1972

Introduction to product design decision-making process

Before delving into the decision-making process itself, one can use a framework like Voice in Decisions Technique[8]. This technique introduces a Framework for Accountable Decision Making, which looks at:

- the "reasons" to help explain or provide a basis for the decision, which are linked to values and preferences.
- The "process" helps explain how the decision is made, the steps and actions taken, and the people involved in making the decision. This is relative to the transparency and reproducibility of the process.
- The "role" helps explain the part people play in the decision. It allows us to question the opportunities for participation in the decision (group decision-making) and the people affected by the decision.

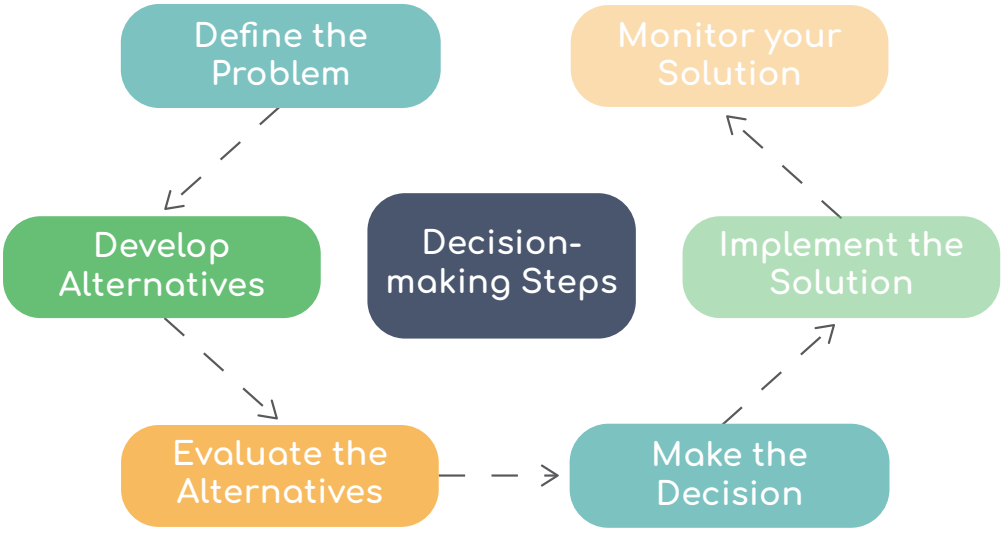
A classical decision-making process deconstructed can be the following:

1. Defining the problem involves questioning the needs and specifying the key objectives.
2. "Develop alternatives" means creating multiple solutions to fulfil a certain need. This involves designing and analysing various options to determine the best possible outcome.
3. Evaluate the alternatives: quantify how far each solution is from the objectives.
4. Make the final decision by selecting the solution that best matches the designer's preferences.
5. Implement the solution
6. Monitor the solution

Decision-making itself can be considered only as the act of choosing between a set of alternatives. But depending on the decision-making problem, the set of alternatives can already exist or have to be created.

It leads to two kinds of approaches:

- Alternatives have to be designed: Each alternative can be found using design methodologies that can include a creative approach or solving an inverse problem in a systemic approach, which requires examining several conflicting criteria; the number of alternatives is either finite or infinite but typically exponentially large.
- Alternatives are explicitly known: The problem is to find the optimal solution for a decision-maker or a set of good alternatives. Each alternative's performance is considered using multiple criteria.



Above Figure 8: Decision-making steps - Based on: https://www.collidu.com/presentation-effective-decision-making

References and Further Reading:

[8.] The Right Question Institute. (2021, November 1). Voice in Decisions Technique - Right Question Institute. Right Question Institute. https://rightquestion.org/vidt/

Above: Zainul Yasni. men and women gathered around a table. May 2019. Unsplash. https://unsplash.com/photos/men-and-women-gathered-around-a-table-QiIxg_q2vh0

Tools are available to assist the decision-maker in both scenarios. However, selecting and balancing criteria is an essential aspect, making decision-making a complex cognitive task. Applying decision-making to the same data may result in very different outcomes, known as the "decision-making paradox." .

One way to deconstruct the decision-making process is by considering two main activities that occur before making the decision.

1. Problem setting: understanding the needs and specifying the designer's preferences.
2. Problem-solving: investigating the given information, finding feasible solutions, and quantifying the criteria.

Problem-solving is often considered a complicated task instead of a complex one. Thanks to computational facilities, it is "easy" to evaluate multiple alternatives and find the ones that best meet the specifications. A typical problem-solving sequence can be:

1. Using physical system modelling, perform simulations to evaluate criteria and calculate requirements for a given product. The simulation solves the "direct problem" and considers attributes such as geometry and physical properties to determine efficiency, cost, environmental impact, and other factors.
2. Optimise attributes to find feasible alternatives. The optimisation solves the "inverse problem" of finding attributes that meet goals.

Product design is more than "simple" problem-solving and is a challenging cognitive task. Indeed, it is not only an inverse problem; it is solving an ill-defined problem (Batres, 2022).

Resource: An example of a design methodology is applied at MIT School of Engineering for tackling ill-structured problems [10].

Prior or posterior preference modelling

The decision-making process involves reasoning based on assumptions about the decision-maker's values, preferences, and beliefs. It's important to recognise that there's usually no one perfect solution, so the decision-maker's preferences must be used to distinguish between all feasible options. This process can be described as a set of orderings that reflect human preferences for one thing over another.

There are three main categories of multi-criteria decision-making approaches depending on how preferences are modelled between problem-setting and problem-solving.

Prior Preferences:
Transforming problems into single-criterion problems.

Progressive or Interactive Preferences:
Incorporating decision-maker preferences through-out the solution process.

Posterior Preferences:
Addressing multiple-criteria problem-solving to define a set of potential alternatives.

In this chapter, we are looking only at prior and posterior articulation preferences

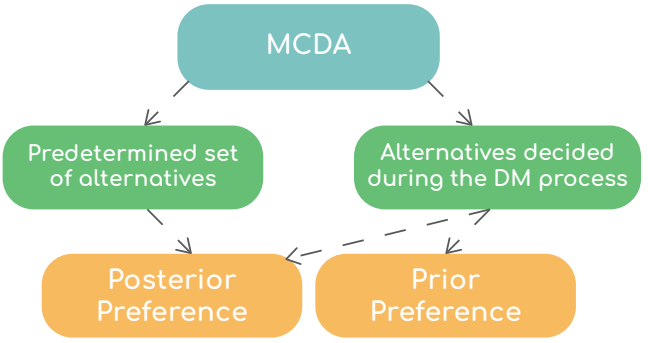


Figure 9: Articulation of preference modeling between problem setting and problem solving

Finding alternatives with:

- Prior preferences: A value function can be defined to rank alternatives automatically during solution space exploration, which allow for instance optimisation algorithms to choose the best possible solution.
- Posterior preferences: If there are no specific preferences on the criteria, exploring alternatives can use the concept of dominance to identify a set of optimal solutions. Conflicting criteria, where improving one generally leads to the degradation of another, do not have a unique solution. In such cases, positive interactive criteria or antagonist effects can be used.

By definition alternative a1 dominates a2, if :

+ a1 is no worse than a2 in all criteria
+ a1 is strictly better than a2 in at least one criteria

The non-dominated set (NDS) is a set of all the solutions not dominated by any other solution. The NDS of the entire feasible decision space is called the Pareto-optimal set, and the boundary defined by the set of all points mapped from the Pareto optimal set is called the Pareto-optimal front.

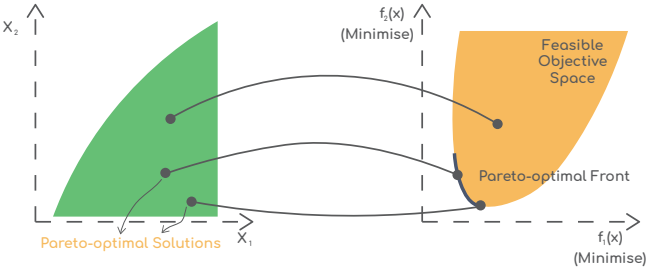


Figure 10: Pareto front - non-dominated set of alternatives

References and Further Reading:

[9.] Triantaphyllou, Evangelos (2000). Multi-criteria decision making methods: a comparative study. Applied optimization. Vol. 44. Dordrecht, Netherlands: Kluwer Academic Publishers. p. 320. doi:10.1007/978-1-4757-3157-6

[10.] Lavi, R. (2024) 'Decarbonizing Ulaanbaatar: Using DIMES-FIRST methodology to tackle a climate and sustainability challenge,' Medium, 8 February. https://medium.com/@realavi_58810/decarbonizing-ulaanbaatar-using-dimes-first-to-tackle-a-climate-and-sustainability-challenge-e8f7e6fee715.

Above: Ceri Almrott. Developing low-tech educational frameworks. ENSE^3, Grenoble. June 2023.

3: Multiple-Criteria Decision-Aiding (MCDA) methods

Problem statement

- MCDA is a methodology for supporting decision-makers facing multiple conflicting criteria. As previously described, there is no unique optimal solution for such a problem, and the decision-maker's preferences must be used to differentiate between alternatives.

Depending on the method and preferences, the problem statement can be:

+ Choice: choosing the best alternative.
+ Ranking: consists of imposing a preference relation on the set of alternatives, i.e., listing them from the best to the worst.
+ Sorting (classifying, clustering): assigns the alternatives to preference-ordered clusters.

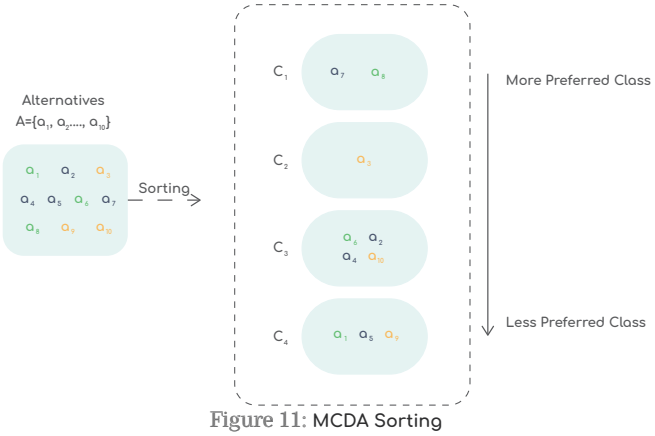


Figure 11: MCDA Sorting

Measurement scale

This final recommendation can be based on scores of alternatives, on binary relations, or on decision rules:

- Scoring: can result in a cardinal recommendation type, where the distance between each al-ternative is quantitatively meaningful.
- Binary relations: leads to an ordinal recommendation, where only the position of the alternatives is meaningful (e.g., ordering of the criteria, pairwise comparisons).
- A third but more specific approach is decision rules, which are based on logical "if..., then..." statements that represent scenarios of a causal relationship between the perfor-mance of alternatives on a subset of criteria and a comprehensive judgment.

There are two types of measurement scales for scoring and binary relations: qualitative and quantitative preference models. MCDA methods are designed to work with a specific type of measurement. Some methods take into account the distance between performance by using the quantitative nature of the input, while others only use the qualitative nature of the input.

- Cardinal scale (quantitative): Like interval and ratio, it can be applied to continuous or discrete data. It mostly belongs to the physical-technical application areas.
- Ordinal scale (qualitative): This scale is used for ranking, but the distance between values is unknown. It is prevalent in the socio-ecology-economic domains.

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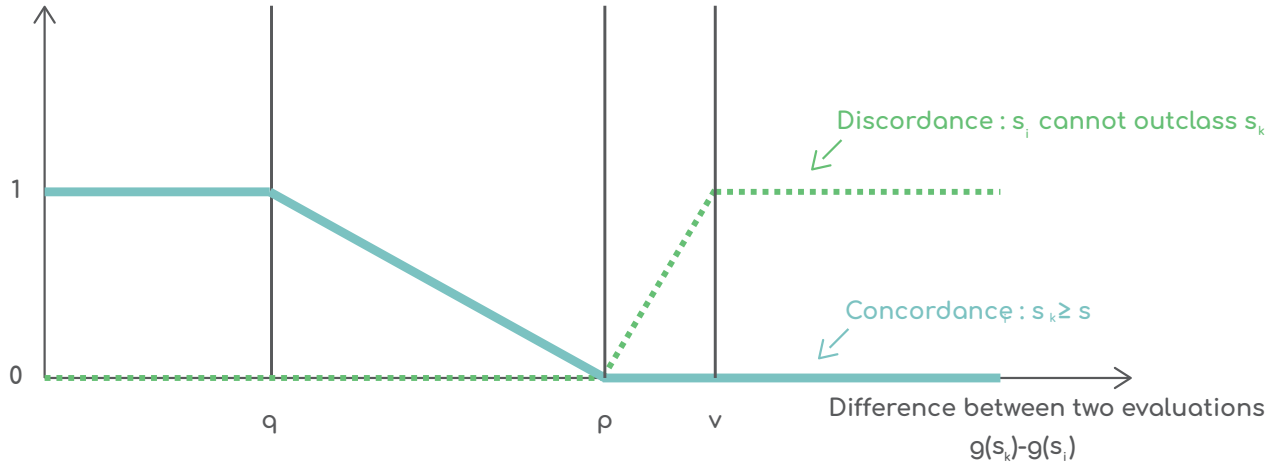

Figure 12: Thresholds for pairwise comparison (Electre III)

Scoring function or Binary relations

Scoring functions are obtained based on a weighting of the criteria to express their relative importance. The ratio can express trade-offs (compensation or substitution rate) between criteria, meaning how much of one criterion compensates for a unit change of the other criterion. Different aggregation rules can implement a normalisation procedure with weights to scale all criteria. Normalisation methods:

- cardinal : use differences in the performance like min-max, target, and distance to a reference, and apply a linear transformation (or piecewise linear, or non-linear)
- ordinal : general approaches driven by the ordinal nature of the data. Like rank, percentile rank, and categorical, which use the position of the alternative in the ranking

Outranking relations and pairwise comparison thresholds can be used to handle uncertainty in performance measurement and the DM's hesitation.

For instance Electre III (Roy, 1977) defines 3 thresholds for pairwise comparison between two solutions $\{s_i, s_k\}$ and their associated performances on one criteria $\{g(s_i), g(s_k)\}$: (see below)

- q: indifference thresholds account for the maximum difference that makes two alternatives indifferent.
- p: preference thresholds consider the minimum difference in performance that leads to a full preference for one alternative.
- v: veto thresholds can be used to enforce fully non-compensatory modelling. This threshold guarantees that when an alternative performs worse than another by at least the veto value on even a single criterion, the former cannot outrank (i.e., be considered as good as) the latter, irrespective of its comparative performance on the remaining criteria.

Outranking methods perform pairwise comparisons of the alternatives, leading to an outranking matrix representing a directed graph where alternatives are in nodes and outranking relations are on arcs. The quality of each alternative depends on its relations with all the other alternatives.

This matrix is then exploited using different algorithms (e.g., net flow score procedures or approaches for identifying a graph kernel) to develop the final recommendation.

Other methods examples:

- Analytical Hierarchy Process: AHP finds priorities of the alternatives using pairwise comparisons of alternatives provided by the DM for each criterion.
- TOPSIS: distance-based. Using Fuzzy information.

(Moffett, 2006) proposes a classification of methods that use the information without any weights (Figure 13), like the non-dominated set (NDS) computation and maximin, moving then to those that use qualitative weights and finally to those that use quantitative weights.

Choosing MCDA Methods

A taxonomy is proposed by (Cinelli et al. 2020), which provides useful information to help choosing a method. It is important to consider the decision-making paradox when choosing a method for decision-making as there is no single best method. One way to choose a method is by using certain criteria such as the ease of use. Ease of use refers to the amount of time it takes to interact with the decision maker and obtain preference information, as well as the level of input required from stakeholders. Another important factor is the processing time and effort needed to gather the data required for the technique, which can vary depending on the chosen method.

Easiness of use :

- Easy : ELECTRE I
- High : AHP, DRSA sorting, TOPSIS

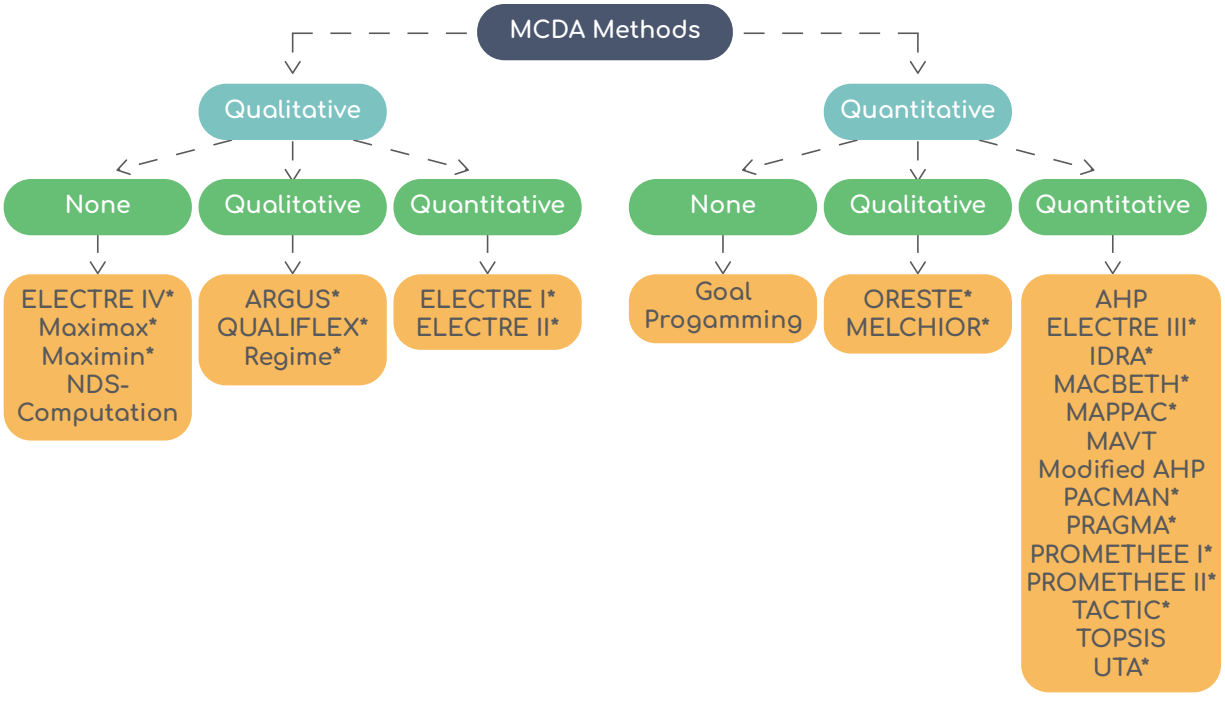

Figure 13: Moffett MCDA methods classification

Taxonomy of the MCDA process characteristics (c.) and sub-characterisitcs (c.x.)							Frequency	%
Phase 1: Problem formulation	c.1 - Problem typology	c.1.1 - Problem statement	Choice				25	45
			Ranking				42	75
			Sorting				26	46
		c.1.2 - Problem variability (alternatives n.)	Stable				5	9
			Incremental				5	9
	c.2 - Criteria	c.2.1 - Structure	Flat				18	32
			Hierarchical				18	32
		c.2.2 - Evaluation of performance	c.2.2.1 - Measurement Scale	Interval			39	70
				Ordinal			39	70
				Ratio			39	70
			c.2.2.2 - Performance Type	Deterministic			14	25
				Uncertain	DIS		7	13
					ER		3	5
					FU		14	25
					GN		1	2
					JM		7	13
					LV		1	2
					PD		16	29
					PT		1	2
					PV		12	21

Taxonomy of the MCDA process characteristics (c.) and sub-characterisitcs (c.x.)							Frequency	%
Phase 2: Construction of the decision recommendation	c.3 - Elicitation of preferences	c.3.1 - Direct	c.3.1.1 - Weight Type	c.3.1.1.1 - Subjective	JM		12	21
					Precise	IC	20	36
						TOF	25	45
					Imprecise	CON	2	4
						FU	2	4
						INT	1	2
						JM	8	14
						MI	2	4
						ORD	10	18
						PWC	3	5
						Ratio	2	4
				c.3.1.1.2 - Objective	COR		2	4
					DEA		4	7
					EM		2	4
					FA		3	5
					JM		1	2
					PCA		5	9
					RA		3	5
					UCM		2	4
			c.3.1.2 - No Weights				8	14

Taxonomy of the MCDA process characteristics (c.) and sub-characterisitcs (c.x.)							Frequency	%
Phase 2: Construction of the decision recommendation	c.3 - Elicitation of preferences	c.3.1 - Direct	c.3.1.3 - Pairwise comparison thresholds	JM			2	4
				Indifference			24	43
				Preference			24	43
				Veto			20	36
			c.3.1.4 - Interactions between criteria				6	11
			c.3.1.5 - Preference models	Scoring Functions	JM		22	39
					Intensity of preference on a ratio scale		24	43
					Normalisation method	GEN	8	14
						LIN	17	30
						NLI	10	18
						PLI	10	18
				Binary relations			33	59
				Decision rules			11	20
		c.3.2 - Indirect	c.3.2.1 - Frequency of preference provision			INC	7	13
						OT	7	13
			c.3.2.2 - Elicitation approach			AAC	2	4
						CAI	1	2
						JM	5	9
						ORA	2	4
						PWA	3	5

Taxonomy of the MCDA process characteristics (c.) and sub-characterisitcs (c.x.)				Frequency	%
Phase 2: Construction of the decision recommendation	c.4 - Features of aggregation	c.4.1 - Compensation level between criteria	Full	33	59
			None	32	57
			Partial	30	54
		c.4.2 - MCDA method capacity to handle inconsistent preferences		2	4
		c.4.3 - MCDA method decision context dependency	Dependent	11	20
			independent	10	18
	c.5 - Exploitation of the model	c.5.1 - Univocal recommendation		56	100
		c.5.2 - Robustness assessment	Exact	3	5
			JM	8	14
			Stochastic	12	21
		c.5.3 - Group decision		14	25
Phase 3: Qualitative features and technical support	c.6 - Easiness of use / Understandability of the method			20	36
	c.7 - Processing amount needed to compile the data required for the method			3	5
	c.8 - N. alternatives and/or criteria			10	18
	c.9 - Extent of use of the method in the specific context/area			2	4
	c.10 - Software support and graphical representation			7	13

AAC	CAI	CON	COR	DEA	DIS	EM	ER	FA	FU	GEN
Assignment of some alternatives to categories	Comparisons of some alternatives with respect to intensity of preference	Constraint-based	Correlations	Data Envelopment Analysis	Deterministic intervals / Scenarios	Entropy method	Evidential reasoning	Factor analysis	Fuzzy	General (respect ordinal character, e.g. rank, percentile rank, categorical)

GN	IC	INC	INT	JM	LIN	LV	MI	NLI	AAC	AAC
Grey numbers	Relative importance coefficients (precise)	Incremental	Intervals	Just mentioned	Linear (min/max, target, distance to a reference)	Linguistic variables	Missing	Non-linear	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference

AAC	AAC	AAC	AAC	AAC	AAC	AAC	AAC	AAC	AAC	AAC
Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference	Comparisons of some alternatives with respect to intensity of preference

Above Figure 14: Cinelli MCDA methods taxonomy

ELECTRE methods (easy)

The ELECTRE method is an outranking approach that is known for its flexibility. It allows for the direct evaluation of alternatives based on each criterion, without the need for normalization. Furthermore, the method can be used to evaluate both qualitative and quantitative criteria scales. However, to use the ELECTRE family of methods, one needs to define the degree of importance (w) or certain threshold parameters such as indifference, preference, and veto thresholds (q, p, and v) as depicted in Figure 12 for ELECTRE III. Here is a proposition of simplified method inspired from ELECTRE I.

Let $\mathscr{C}$ be the set of criteria. Let $\mathscr{A}$ be the set of stocks or options to be compared.

For each criterion $i \in \mathscr{C}$, we ask that the decision-maker be able to say, $\forall a, b \in \mathscr{A}$, whether a is at least as good as b or not, with respect to this criterion. This is denoted $a \succ ib$ or $a \not\succ ib$. We also allow the decision-maker to say that on criterion i, a is really much better than b. And this is noted $a \succ\succ_i b$.

We then determine, $\forall a, b \in \mathscr{A}$, the set of criteria for which there is agreement (or concordance) to say that a is at least as good as $b : C(a,b) = \{i \in C\}$, as well as the set of criteria for which there is strong opposition (veto or discordance) to say that a is at least as good as $b : D(a,b) = \{i \in C : b \succ\succ_i a\}$.

Overall, a is said to be at least as good as b if the agreement is strong enough and there is no disagreement. We then say that a outperforms b, which is denoted aSb.

If we associate a weight $w_i \geq 0$ to each criterion $i \in \mathscr{C}$, such that $\sum i \in C_w = 1$. Then we can say that:

$$aSb \Leftrightarrow \sum_{i \in C(a,b)} w_i \geq \lambda \wedge D\left(a,b\right) = \emptyset$$

where $\lambda \in]0.5, 1]$ is the minimum agreement threshold for a coalition of criteria to lead to an overall preference.

The outranking relation is a binary relation, since aSb is either true or false.

In an optimistic approach, we can calculate the "outflow" of the relationship, which corresponds to the number of options that a given option $a \in \mathscr{A}$ outperforms, i.e. $\mathrm{OFS}(a) = \mathrm{card}\{b \in \mathscr{A} : a \ \mathrm{S} \ b\}$ The higher this outflow, the better the option can be considered.

In a pessimistic approach, we can calculate the "inflow" of the relationship, which corresponds to the number of options by which a given option $a \in \mathscr{A}$ is outclassed, i.e. $\mathrm{IFS}(a) = \mathrm{card}\{b \in \mathscr{A} : b \ \mathrm{S} \ a\}$. The higher the inflow, the less the option will be considered good.

Finally, in a neutral approach, we can calculate the "net flow" defined as the difference between the outflow and the inflow: $\mathrm{NFS}(a) = \mathrm{OFS}(a) - \mathrm{IFS}(a)$ and the higher the net flow, the better the option.

These three orders (based on flows) can be used to qualify the recommendation, depending on the context.

Example with ELECTRE III:

https://help.xlstat.com/6713-electre-3-multi-criteria-decision-analysis-excel

AHP method (hard)

The Analytic Hierarchy Process (AHP) is a decision-making tool designed for groups. It helps to quantify the weights of decision criteria by utilising the experiences of individual experts to estimate the relative magnitudes of factors through pair-wise comparisons. Each expert compares the relative importance of each pair of items using a specially designed questionnaire. With the help of the AHP, the relative importance of the criteria can be determined by comparing the requirements. The best alternative can be found based on the specified criteria.

1. The first step is to create a hierarchy model of the problem. The different aspects of the problem must be explored, starting from general to detailed levels, and then expressed in the multilevel format that the AHP requires. When dealing with complex decision-making problems, a hierarchy approach can help integrate large amounts of information and gain a better understanding of the situation. By building this information structure, we can form a more precise and more comprehensive picture of the problem (Saaty, 2008).

2. After constructing a hierarchy, it can be analysed by making pairwise comparisons to create numerical measurement scales for each node. The criteria are compared against the goal to determine their relative importance, while the alternatives are compared against each requirement to determine preference. These comparisons are processed mathematically, resulting in the derivation of priorities for each node. (see Figure 14).

Example: Choosing a family car:
https://en.wikipedia.org/wiki/Analytic_hierarchy_process_%E2%80%93_car_example

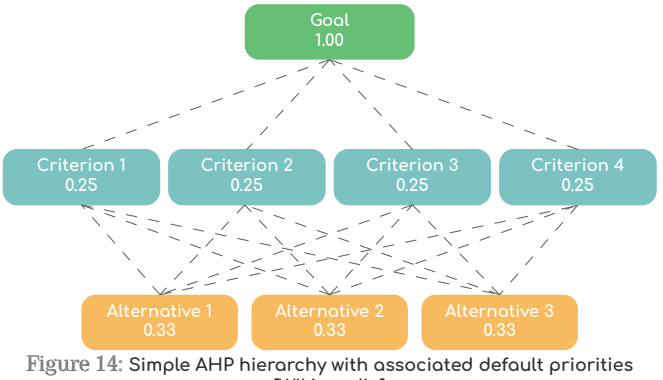

Figure 14: Simple AHP hierarchy with associated default priorities [Wikipaedia]

Above: Giammarco Boscaro. book lot on black wooden shelf. September 2017. Unsplash. https://unsplash.com/photos/book-lot-on-black-wooden-shelf-zeH-ljawHtg

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https://silverdecisions.pl/

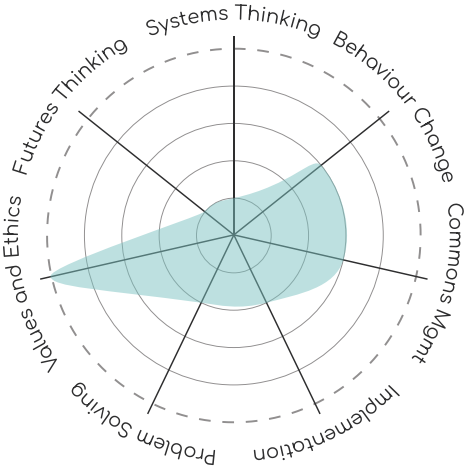
The Imperative of Responsibility

Philippe Fortemps

7 lessons
1 Training Workshop

Above: Novoto Studio. An artist's illustration of artificial intelligence (AI). 2023. Google DeepMind. Pexels. https://www.pexels.com/photo/an-artist-s-illustration-of-artificial-intelligence-ai-this-image-depicts-the-potential-of-ai-for-society-through-3d-visualisations-it-was-created-by-novoto-studio-as-part-of-the-visua-18069494/

The Imperative of Responsibility



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	Online or in person direction	12
Workshop	Ethical Technology Workshop	4
Self-Directed	Online assessment Online debates (kialo-edu.com) Case study assessment	18

Module Objectives

Designers, engineers, and managers have a significant impact on people's well-being and the achievement of sustainable development goals. This is because their work shapes social, cultural, and environmental contexts and relations. Ethical principles and tools are essential to address dilemmas that professionals may encounter. Due to their specific competencies, it is their responsibility to adopt an appropriate ethical reflection. The current module is named after Hans Jonas' book.

Learning Outcomes

Through study in this module learners will:

Define and understand the great classical and contemporary approaches in ethics.

Deliberate to make and argue a contemporary ethical judgment on a proposed solution in an identified situation.

Understand the current emergence and emergency of low-tech approaches.

Critically evaluate the low-tech approaches with respect to contemporary ethical issues.

Be a responsible actor, in their personal life, in teams and in design processes.

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Above: Gu Evary. Person Jumping from Natural Arch over Sea Shore. Pexels. https://www.pexels.com/photo/person-jumping-from-natural-arch-over-sea-shore-20068515/

1: What is Ethics? What is a human being?

One can define ethics (also known as moral philosophy) as:

"the questioning that precedes the introduction of the idea of morality, with the aim of living well with and for others in just institutions." [1]

While morality consists of describing, discerning, or prescribing what is right and wrong, ethics establishes rational and systematic approaches to understanding, evaluating, and making moral decisions with the aim of living well. In other words, ethics questions the foundations of morality. In this way, it enables us to address new, complex, and uncomfortable ethical issues. They are called dilemmas because we face a limited set of possible actions, all open to criticism.

Ethics, therefore, is not a collection of "ready-to-think" or "ready-to-decide" products. It is preparation for contextualised analysis in a given moment and situation, with identified stakeholders, leading to a decision. Like any rational activity, ethical questioning has its own methods, rigour, and premises.

Ethical agents find themselves torn between conflicting issues. Frequently, they have no other option but to choose and resolve to carry out the least bad action, i.e., the one they can live with. So, ethics cannot be based on a single, stable and definitive foundation that would settle once and for all the questions that might arise. There is no body of universally established certainties but rather a pluralism of virtues, principles, and values.

- An ethical value consists of a foundational belief about what is ethically important: justice, happiness, dignity, autonomy, friendship, wisdom... A value can be identified as a supreme good if it is intrinsically good and sought solely for its own sake and not merely as an instrument for another end.
- An ethical principle is a general, actionable rule that guides ethical behaviour. For example, remember the golden rule: don't do to others what you wouldn't want done to you.
- An ethical virtue is a positive character quality that describes individuals acting ethically. Examples include integrity, courage, and responsibility.

Ethics is not just about individuals. It can also concern social or societal choices and institutions. In such cases, ethics must enable us to identify the right decisions, interact with them, communicate them, and justify them to as many people as possible. Such a process of ethical discernment naturally includes a dimension of dialogue.

Ethics goes beyond the law. The law often contains norms that may originate in ethical considerations and social compromises, making them more concrete and operational. However, other factors, such as economic issues, can influence the law differently from ethics. There may be circumstances where ethics is more demanding than the law. Was it ethical to tolerate slavery? What about the unequal rights for men and women?

Occasionally, ethical considerations demand that an individual deviate from the prevailing norms of their community. This can occur within a company, referred to as whistleblowing, or at the national level, known as conscientious objection. For instance, in authoritarian or totalitarian states, would it be ethical to conform to societal standards?

Human being and the Tribe

An ethical thinker acts as an observer of himself, of others and Society. Imagine you are an observer with cannibals... Obviously, a question burns in your mind: "Why do you eat human beings?" It's an eminently ethical question that fascinates you! Your interlocutor will reply that "those who know cannibals know that they don't eat human beings because they risk being put to death on the spot for taking a human life". But then you might protest: "Wasn't that a man I just saw you put in the pot?" "Of course not," he will reply, shaking his head firmly. "But then, what is a human being?" you might ask anxiously, realising the crucial nature of the answer... "A member of the Tribe!"

This thought experiment[2] highlights the significance of the question, "What is a human being?" The answer to this question can significantly affect the extent of our ethics, as well as our perspective on what is right or just, as it determines the group we identify with.

References and Further Reading:

[1.] Ricoeur, P. (1992). Oneself as another. The University of Chicago Press.
[2.] Inspired from Raymond J. Nogar (1998), The Lord of the Absurd

Above: Rohit Sharma. Woman in Traditional Clothing Standing in Lake Water for Ritual. November 2024. Pexels. https://www.pexels.com/photo/woman-in-traditional-clothing-standing-in-lake-water-for-ritual-20074741/

Class Activities

Ethics:

Gather learners in small groups of 5 to 7 members. Ask them to think what the word "ethics" means and to prepare a short definition. Let them write their response on the board and then compare the different propositions.

Then, propose a more formal definition (by example, the one by Paul Ricoeur presented at the beginning of current class) and stress the differences and the similarities.

Ask learners to propose examples of contexts where morality is not sufficient and where dilemmas are present.

Values and Principles:

Gather learners in small groups. Ask them in teams to identify an ethical dilemma (in their daily life, in their professional context, in current events...), i.e., a problem whose solution is not obvious because it brings at least 2 values, principles, or virtues into conflict. If needed, propose one of the following dilemmas:

I. A friend tells you that he cheated on a test. He asks you not to tell anyone.

II. A classmate is bullied by a group of students. Do you intervene?

III. A member of your team is not contributing equally to the work. What should you do?

Ask learners to highlight the conflicting values, principles, and virtues, while identifying the stakeholders in the dilemma: decision-makers, beneficiaries, etc. If several values or principles are involved, try to establish a hierarchy.
Facilitate a whole-class discussion where teams share their thoughts on their ethical dilemmas. Encourage learners to justify their decisions and consider alternative perspectives.

Human being and the Tribe:

Ask learners to take individually a moment to identify the adjective (or short expression) that they think best defines a human being. They don't need to look for an exhaustive definition, just the word that seems most meaningful to them.

Invite the learners, in pairs, to exchange the paper on which they have written their adjective. Then ask them to think about what the implications might be. What is the natural scope of their Tribe? How can this adjective lead them to the definition of the value that can guide the discernment of the Good?

Above: Magnus Flechsenhaar. City tramway on paved street in sunset. February 2020. Pexels. https://www.pexels.com/photo/city-tramway-on-paved-street-in-sunset-3841412/

2: Classical ethical approaches

Three Classical Approaches

Classically, there are three main types of ethical approaches. They can be seen as three angles of view of the human being that complement each other to inform ethical discussion. Considering these three perspectives enriches ethical discernment because they sometimes lead to different recommendations.

- If you consider the human being primarily as a sentient being, you will focus on the effects of actions. This is the realm of consequentialist ethics, also known as utilitarianism, where the moral worth of an action is determined by its outcomes.
- If you consider humans to be mainly logical, you will focus on the admissibility of actions with respect to rules, principles, and reason. You will then refer to deontological approaches such as Kant's deontologism.
- If you consider human beings mainly as agents looking out for their own, you will focus on the inherent qualities of ethical agents. You will then refer to virtue ethics, which is Aristotle's approach.

Consequentialism

In Consequentialism, an action is ethically valued only with respect to the difference between the sum of pleasures and the sum of pains implied by this action. This is the principle of utility. On the other hand, there is a principle of impartiality: the ethical agent must consider the utility of the action for all the concerned individuals on an equal basis. This can be summarised in Jeremy Bentham's expression, "It is the greatest happiness of the greatest number that is the measure of right and wrong."

Other consequentialists, such as John Stuart Mill, have insisted on incorporating other dimensions into utilitarianism, highlighting a hierarchy among human desires, with lower and higher pleasures or pains.

Utilitarianism is a demanding ethical approach because it seeks not just a better condition for humanity but the most satisfied humanity, putting all the concerned people on the same footing.

Moreover, it should also be noted that the starting point was to consider the human being a sentient being... We must, therefore, also consider other sentient beings, such as animals and even plants, in the scope of this ethics.

Deontologism

In Deontologism, an action is ethical if compatible with the duty to satisfy moral laws and ethical reason. Everyone knows the Golden Rule, which can be considered a moral law. However, deontologists, such as Kant, looked for autonomous ethical justification. He introduced the maxim as a personal rule of action that agents give themselves. Such a rule is to be consistent with freedom and reason; it makes sense to require that it is universalisable. In other words, "Can my desire for action become the law of action for everyone?" Above this minimum requirement to be reasonably legitimate, Kant also requires respect for human dignity.

Other deontologists have insisted that unconditional duties can lead to immoral situations (e.g., telling the truth to a murderer looking for his victim). This shows that an agent's duties may only exist in response to the rights of other agents.

Deontologism proposes three tools to filter the set of potential actions: first, if an action cannot be universalisable, this action is considered as intrinsically immoral, whatever the beneficial consequences that might be hoped for in the current situation. Then, human dignity is an inescapable criterion for our actions: a person can never be treated as a mere mean. Finally, an action may only become an ethical duty if it corresponds to someone's rights.

Virtue

Every human being naturally aspires to be a 'good person' in their own eyes and the eyes of those around them. For Aristotle, a person's self-flourishing corresponds both to their intrinsic qualities and to the development of these qualities in practice. These qualities are known as virtues.

First and foremost, the virtue of Practical Wisdom enables us to discern the right attitude to adopt in each situation. Other virtues include courage, friendship, justice, benevolence, tolerance, and open-mindedness... Each virtue is a golden mean between two excesses or, more precisely, a flexible middle ground to be discerned according to circumstances, emotions, or context. For example, courage is a golden mean between cowardice and recklessness in the face of fear. As for friendship, it is the right attitude between its vice by default (the cantankerousness) and vice by excess (the self-serving flattery).

The acquisition of these virtues is the result of an ongoing process of self-improvement; on the one hand, by practising each virtue, like a sportsman practises his sport to become a virtuoso, and on the other hand, by drawing on selected ethical heroes, we want to be like. Thus, every choice implies the possibility of the agent's ethical improvement.

Above: Mehmet Turgut Kirkgoz. Street Sweeper at Work. September 2022. Pexels. https://www.pexels.com/photo/street-sweeper-at-work-13695369/

Class Activities

Start by proposing some of the following quotes to groups of learners. Invite them to highlight the differences. Ask them to identify the approach that best suits them. One of them... or a combination of the three? Groups can then share their thoughts with others. Finally, teachers can formally define the approaches.

Consequentialism:

a. Jeremy Bentham (1748-1832): "Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we shall do. On the one hand the standard of right and wrong, on the other the chain of causes and effects, are fastened to their throne. They govern us in all we do, in all we say, in all we think (...)." "Sum up all the values of all the pleasures on the one side, and those of all the pains on the other (...)."

b. John Stuart Mill (1806-1873): "Few human creatures would consent to be changed into any of the lower animals, for a promise of the fullest allowance of a beast's pleasures; no intelligent human being would consent to be a fool, no instructed person would be an ignoramus, no person of feeling and conscience would be selfish and base, even though they should be persuaded that the fool, the dunce, or the rascal is better satisfied with his lot than they are with theirs."

Deontologism:

a. Immanuel Kant (1724-1804): "Now an action done from duty must wholly exclude the influence of inclination and with it every object of the will, so that nothing remains which can determine the will except objectively the law, and subjectively pure respect for this practical law, and consequently the maxim that I should follow this law even to the thwarting of all my inclinations."

b. Immanuel Kant (1724-1804): "Act only in accordance with that maxim through which you can at the same time will that it becomes a universal law."

c. Immanuel Kant (1724-1804): "Act so that you use humanity, as much in your own person as in the person of every other, always at the same time as end and never merely as means."

Virtues:

a. Aristotle (384-322 BC): "Similarly, the excellence of the horse makes a horse both good in itself and good at running and at carrying its rider and at awaiting the attack of the enemy. Therefore, if this is true in every case, the virtue of man also will be the state of character which makes a man good and which makes him do his own work well."

b. Alasdair MacIntyre (1929—): "Consider the example of a highly intelligent seven-year-old child whom I wish to teach to play chess, although the child has no particular desire to learn the game. The child does however have a very strong desire for candy and little chance of obtaining it. I therefore tell the child that if the child will play chess with me once a week I will give the child 50 cents worth of candy; moreover I tell the child that I will always play in such a way that it will be difficult, but not impossible, for the child to win and that, if the child wins, the child will receive an extra 50 cents worth of candy. Thus motivated the child plays and plays to win. Notice however that, so long as it is the candy alone which provides the child with a good reason for playing chess, the child has no reason not to cheat and every reason to cheat, provided he or she can do so successfully. But, so we may hope, there will come a time when the child will find in those goods specific to chess, in the achievement of a certain highly particular kind of analytical skill, Strategic imagination and competitive intensity, a new set of reasons, reasons now not just for winning on a particular occasion, but for trying to excel in whatever way the game of chess demands. Now if the child cheats, he or she will be defeating not me, but himself or herself."

Above: RDNE Stock project. A Girl Talking to Her Mother using a Laptop. June 2021. Pexels https://www.pexels.com/photo/a-girl-talking-to-her-mother-using-a-laptop-8489039/

3: More contemporary ethical approaches

Care ethics

While classical ethics, which were more influenced by male authors, required ethical agents to be detached from their emotions and indifferent to the people concerned, Care ethics incorporates more feminist ideas. It integrates emotions and human relationships into its reasoning. Inspired by the recent work of the American philosopher Carol Gilligan, this approach involves identifying what is right and what is wrong in a particular situation by recognising the vulnerability of other people and putting ourselves in their shoes.

Since we are essentially social beings, Care ethics considers the dimension of relationships to be fundamental to ethics. Such relationships define the specific responsibilities we have towards people and the natural bias we want to show towards those closest to us. Our choices are guided by our emotions and empathy in a context-dependent way.

Care ethics is associated with action, attitude, and motivation. An appropriate attitude implies compassion, empathy, engagement, and awareness of the interconnections between beings (human and non-human).

These sound very much like virtues, with a new emphasis on the relationship rather than the individual. For example, care ethics will need to take account of vulnerability and dependency, particularly where relationships are not symmetrical. Think of the parent-child relationship, the employer-employee relationship, etc. Each agent has to improve their capacity (virtu) for empathy and compassionate action.

Ubuntu ethics

Ubuntu ethics, in line with important African wisdom, highlights a crucial dimension of our humanity: the relational dimension of the human person.

Our humanity is inextricably linked to that of others: those who have gone before me, those who are my contemporaries and those who will come after me. The key idea is that a human being only becomes fully human through other human beings.
Of course, no one is perfect at Ubuntu. It's an ethics of self-improvement, where practising the ubuntu qualities/virtues (kindness, courtesy, compassion, respect, concern for others...) leads us to improve together. It's about considering how my choices can foster the human community dimension of Ubuntu.

So, while it is personal, it is an ethics that emphasises relationships between people and the community. In such a mindset, we have a dual duty: to improve ourselves, become a better version of ourselves, and enable and help others to become better versions of themselves. Finally, it is important to consider not just human beings but the entire natural environment in which human beings live. This holistic vision places human beings within the continuity of Nature.

The ethical criterion for choosing a particular action is to use one's personal power and resources to commit oneself to the common good rather than to create an isolated individual good or even a plenty of isolated individual goods. An important question that this ethics invites us to consider is the extent to which each of our decisions helps to recreate or strengthen the fundamental social bond of our human community, locally and on the scale of the whole humanity.

Responsibility ethics

Over the years (over the last 300 years or so), humanity has developed a capacity to disrupt Nature and to have an impact on the fate of the planet and, therefore, of humanity as well. From that point of view, Hans Jonas proposed an ethics of responsibility: the present generations must assume their responsibility towards future generations and not shift it onto the shoulders of those future generations. To quote H. Jonas, "We have the right to risk our own lives, but not the lives of humanity".

This kind of responsibility is to be exercised towards humans who do not yet exist or do not have the opportunity to participate in the debate, as well as towards Nature. But H. Jonas finds an example of a similar responsibility in parental responsibility, which is a forward-looking responsibility. It is already exercised before the children are born and gives rise to non-reciprocal duties: parents have moral duties towards their children because of the latter's vulnerability. This responsibility is, therefore, driven as much by reason as by sentiment: a sense of the vulnerability of others to what I can do or decide.

So, for H. Jonas, responsibility is a correlate of power or knowledge. The ethics of responsibility call on us to be extremely cautious out of concern for those who will be the object of the decisions we are about to make, both because of the power or knowledge we possess and because of the long-term effects of these decisions. Such an understanding cannot stand on its own; it creates an additional duty to educate ourselves, know better and measure the consequences: a new ethical obligation to perfect our knowledge and skills in our areas of expertise.

Above: Kureng Workx. Kids Sitting Near the Laptop. August 2017. Pexels. https://www.pexels.com/photo/kids-sitting-near-the-laptop-4314674/

Class Activities

Start by proposing some of the following quotes to groups of learners. Invite them to highlight the differences with classical ethics as well as to highlight contemporary issues. Groups can then share their thoughts with others. Finally, teachers can formally define the approaches.

Care ethics:

a. Carol Gilligan (1936—): "At a time when efforts are being made to eradicate discrimination between the sexes in the search for social equality and justice, the differences between the sexes are being rediscovered." "While men represent powerful activity as assertion and aggression, women in contrast portray acts of nurturance as acts of strength." "While an ethic of justice proceeds from the premise of equality—that everyone should be treated the same—an ethic of care rests on the premise of nonviolence—that no one should be hurt."

b. Nel Noddings (1929—2022): "A great attraction of care ethics, I think, is its refusal to encode or construct a catalog of principles and rules. One who cares must meet the cared-for just as he or she is, as a whole human being with individual needs and interests."

Ubuntu ethics:

a. Nelson Mandela (1918—2013): "A traveller through a country would stop at a village and he didn't have to ask for food or for water. Once he stops, the people give him food and attend him. That is one aspect of Ubuntu, but it will have various aspects. Ubuntu does not mean that people should not address themselves. The question therefore is: Are you going to do so in order to enable the community around you to be able to improve?"

b. Barbara Nussbaum: "Joe Mogodi, a successful businessman in Pietersburg, South Africa, showed his Ubuntu by buying up 100 sewing machines at an auction, which he then made available to men and women in the community who were interested in starting tailoring businesses but did not have the necessary capital. He honoured their dignity by making a simple verbal agreement that they would pay him for the machines once there were sufficient profits to begin interest-free payments."

Responsibility ethics:

a. Hans Jonas (1903—1993): "The finally unbound Prometheus, to whom science confers unprecedented powers and the economy its unbridled impetus, calls for an ethics that, through freely consented restraints, prevents man's power from becoming a curse for him. The opening thesis of this book is that the promise of modern technology has turned into a threat, or that the latter has become indissolubly linked to the former. It goes beyond the observation of a physical threat. The submission of nature to human happiness has led, through the excess of its success, which now also extends to the nature of man himself, to the greatest challenge to the human being that its making has ever entailed."

b. "Act in such a way that the effects of your action are compatible with the permanence of authentically human life on Earth. [...] or simply: do not compromise the conditions for the indefinite survival of humanity on Earth".

c. Ursula Le Guin (1929—2018): "We must learn to keep the balance. Having intelligence, we must not act in ignorance. Having choice, we must not act without responsibility."

Above: Ben White. Woman thinking while leaning against a brick wall. December 2016. Unsplash. https://unsplash.com/photos/woman-praying-while-leaning-against-brick-wall-yy3GonY48N0

4: Ethical Analysis

Ethical analysis is a practical framework that guides individuals and organisations to make decisions and take actions that align with their values, principles, and societal norms. This course will present the ethical analysis process, a structured approach designed to illuminate the ethical dimensions of decisions and actions. The aim is to equip learners with the practical tools and insights necessary to engage in thoughtful, ethical deliberation and make informed, morally sound choices in diverse contexts by exploring a seven-step evaluation process.

State the Question > Identify the Issues > Realise a Survey > Analyse the Dilemma > Deliberate > Decide Ethically > Communicate the Decision

1. State the question:

At first, the ethical question needs to be clearly posed. While such a question can be one of understanding the ethical situation or identifying the stakeholders' points of view and of the positions taken by the different philosophers, the most interesting question is a question of evaluation, justification, or recommendation. The aim is to determine the best (or worst) option to adopt or perhaps to propose a new option. Of course, a good ethical question does not already suggest an answer. It cannot simply consist in confirming an option already taken. The question must freely open several possibilities or even allow such possibilities to be opened through ethical analysis.

2. Identify the issues:

In the second step, all the ethical aspects must be listed. What are the values, principles and virtues to be considered in the light of the question posed? Among other things, this involves considering the various impacts of the decision on the various stakeholders. Besides the public's or field specialists' opinions, it is interesting to consider various publications (general or specialised scientific literature). An essential point in applying an ethical approach to a technology lies in identifying the intrinsic values of the human activity that the technology will impact.

3. Realise a survey:

An ethical survey consists of consulting people beyond the circle of reflection to find out what they have to say about understanding, identifying, evaluating, and recommending ethical propositions. The scientific or ethical press can provide information on current practices or thinking in the field. The general media will provide information on public opinion. The survey can also involve interviews or even a poll. In this case, an interview guide or a progressive and adaptive questionnaire should be drawn up. For example, a sequence of increasingly difficult ethical scenarios can help to identify the breaking point at which a proposal goes from being ethically acceptable to ethically unacceptable.

4. Analyse the dilemma:

This step addresses the ethical question studied according to the ethical approaches identified in the previous chapters. It is important not to limit ourselves to a single ethical approach, however good it may be. On the one hand, each ethical approach has its own bias and way of looking at an ethical question. Therefore, formulating several approaches makes it possible to enrich points of view and lead to more nuanced assessments. On the other hand, each individual acts with a preferred ethics; this may correspond to one of the ethical approaches presented above or to a specific combination of several of these approaches. Formally considering several approaches makes it easier to come to terms with the points of view of the various people involved in the decision.

5.Deliberate:

Today, ethics can only be conceived in terms of dialogue, debate, and deliberation. The importance and complexity of the questions mean that ethical reflection must occur within a think-tank that sufficiently involves the various stakeholders. Ethical deliberation can be defined as a process concerning a group of persons looking for an ethical decision through the exchange of information, the critical exploration of a question and the common building of an argumentation. Such a deliberation must include representatives of all stakeholders as early as possible, enjoy an effective impact on the decision-making process, and be transparent and resource-effective.

6.Decide:

An ethical analysis is a process that aims to make a decision. This decision may not be as simple as just a "yes" or "no." It can also lead to new proposals that can take on various forms, such as innovative recommendations. This makes the ethical analysis process a crucial part of the design process.

However, making a decision is not enough. It needs to be accompanied by a thorough argumentation that lays out all the reasons that led to the proposal. This should include arguments for the chosen proposal and against the others, as well as arguments against the chosen proposal and in favor of the others. It's important to provide the full range of ethical arguments that made the decision possible.

7. Communicate:

When communicating the decision and its arguments, care should be taken to ensure that the wording is accessible to all the stakeholders concerned. Technical and ethical jargon should be avoided. As mentioned earlier, this communication is necessary to ensure the transparency of the deliberation process.

Above: Oladimeji Ajegbile. Photo of Man Writing On Notebook. September 2019. Pexels. https://www.pexels.com/photo/photo-of-man-writing-on-notebook-2989397/

Class Activities

The best thing, of course, is to allow teams of learners to carry out the proposed ethical analysis process step by step. Below are a few points to bear in mind at each step.

1. **Ethical question:** If learners can themselves propose the ethical question that interests them, they will be more involved in the learning process. It is important to ensure that the question is open-ended and, ideally, that it can lead to recommendations about what should be done... or what should have been done.
2. **Ethical issues:** We recommend starting by listing the stakeholders as broadly as possible, before, if necessary, reducing the number to a reasonable value. An important point is to state the intrinsic value of the situation concerned. For example, the exercise of justice can be seen as a punitive task (what punishment should be applied to a particular criminal?) or a restorative one (how can we repair the way we live together?). In the first case, the value is the proportionality and the consistency of the punishment. In the second case, the value is the social link to be rebuilt. Values and principles should come at the end of the current step.
3. **Ethical survey:** The difficulty with documents (written, audio or video) is to obtain sufficiently rich and complete information to answer the three levels of the ethical question. Often, in fact, we will find documents that only address the understanding or the identification of the ethics issues. Others will provide an assessment or a recommendation, but without proposing an explicit reflective pathway.
4. **Ethical analysis:** This stage requires the learners to reposition themselves each time in the mindset specific to each ethical approach. This can be a real challenge for some learners; teachers should support the learners in this.
5. **Deliberation:** Each team can propose a debate to other learners, around their ethical dilemma. In such a case, the practice of Samoan circles can be recommended. This is a debate process in which all participants are put on an equal footing, while organising an effective exchange of arguments. The participants are divided into two concentric circles: only those in the inner circle may speak, but they must regularly make way for participants from the outer circle. To begin with, care is taken to ensure that all points of view are represented in the inner circle.
6. **Decision:** Each team makes explicit the arguments against/in favour of various proposals for a decision. Moreover, they can recommend one of the initial proposals, or argue in favour of a new proposal they present.
7. **Communication:** Each team drafts a written report, adapting the arguments to the decision's main target audience.

The training workshop at the end of this module will propose additional activities that can be used for different steps of the ethical analysis.

Above: Warren Wong. person wearing black and red hoodie holding smoke bomb. August 2017. Unsplash. https://unsplash.com/photos/person-wearing-black-and-red-hoodie-holding-smoke-bomb-bh4LQHcOcxE

5: Be an ethical actor

The aim of this class is not to provide a complete course on ethical organisational behaviour. Instead, we shed light on some principles relevant to being an ethical actor in a low-tech design process.

Moral integrity

The moral integrity of each implied agent is desirable for all stakeholders to have long-term confidence in the various parties involved and to anticipate their behaviour reasonably. This requires both external consistency and internal coherence and consistency. External consistency refers to the logical alignment between what the agent says or claims and what they do or accomplish. Internal consistency is the logical alignment between the agent's beliefs, values, or principles. Internal coherence reflects the consistency of the belief or value system.

Moral integrity means assuming the same ethical principles or values in each agent's whole life, beliefs and claims, individual or organisational behaviour, and project-related decisions. Any inconsistency in this regard can harm moral agents' relationships with others and put the credibility of their choices at risk. Inconsistencies will be quickly noticed and criticised, as they can be interpreted as dishonesty.

Subsidiarity

The principle of subsidiarity, which has its roots in the writings of Alexis de Tocqueville (1805-1859), suggests that a decision, task, or action should be handled by the level of authority closest to those directly affected. Generally, this level is the one most capable of effectively performing the task at hand.

In the Design Thinking process , the journey begins with an empathy phase, where needs are discovered and listened to. However, it is the test and acceptance phase that truly empowers end-users, as they are entrusted with the final decision to approve the proposed product.

In a product or system designed with the principle of subsidiarity in mind, the user is empowered to make effective choices. It is not the engineer's or designer's role to impose their choices on the user in a paternalistic manner. Such an approach would disregard the user's dignity and autonomy.

Co-design

For a long time, designers, engineers, and managers saw themselves as experts: they did not need to listen to users or even need to listen to each other. So, they designed prodigious products, services, and systems, but they did not necessarily meet end-users real needs.

Co-design brings together participative, open and co-creation design processes. It originated in the participatory approach developed in Scandinavia in the 70s, which included the end-users as the experts in the design process. More precisely, it involves genuine cooperation with users throughout the design process, relying on the strengths of "collective intelligence". It requires to give power and skills for each stakeholder to participate actively and efficiently.

Sobriety / sufficiency

Any co-design project can encounter inherent difficulties. Indeed, when several stakeholders contribute, there is a risk of adding functionalities or improving the technology without any real need. Therefore, the principle of sobriety/sufficiency can be applied to curb undue project drift. First, the design process needs to define a clear, ambitious, but limited scope. Changes are certainly possible, but they will not always be accepted. Then, one must choose the appropriate level of quality and technology, avoiding any gold-plating finishers or useless sophisticated technologies.

Knowing how and when to say "no" is the professional attitude and skill of a project manager who is aware of the various limitations of the design process. Not everything is feasible, given the limited resources or available skills. To go beyond this would involve unacceptable risks.

Links to other content in the Book:
Effectiveness, Efficiency, Sobriety (p.149)

References and Further Reading:
[3.] IDEO U. (n.d.). Design thinking framework, Innovation & Methodology. IDEO U. https://www.ideou.com/pages/design-thinking

Above: Ehimetalor Akhere Unuabona. London Black Lives Matter Peaceful Protest from Hyde Park to Trafalgar Square. June 2020. Unsplash. https://unsplash.com/photos/man-in-blue-jacket-holding-red-and-white-plastic-cup-72doRdFx-Lo

Class Activities

To go further, learners can be invited to see how these character traits recommended for an ethical agent are integrated into Low-Tech approaches, for example in the Low-Tech Lab **(see the website: https://lowtechlab.org/en/)**.

- The "external consistency" in the moral integrity principle is aligned with the Low-Tech Lab principles. Indeed, before advocating for a system or an organization, project managers must experiment with it. See
  - **the Low-Tech Explorer program:** https://lowtechlab.org/en/the-low-tech-lab/our-actions/explorer-program
  - **the Biosphere experience:** https://lowtechlab.org/en/the-low-tech-lab/our-actions/biosphere-2018
  - **the Low-Tech Lab charter** https://wiki.lowtechlab.org/images/a/ad/Monter_une_Communaut_Locale_Low-tech_Lab_Charter_Signature_EN_.pdf
- The subsidiarity principle is at the core of the values of the Low-Tech Lab. See for examples:
  - **the report on the Low-Tech habitat:** https://lowtechlab.org/media/pages/le-low-tech-lab/les-actions/habitat-low-tech/a4127aaf37-1638190947/hlt_-_global_-_web_-_anglais_-_vf.pdf (p. 7)
  - **the Low-Tech Lab charter** https://wiki.lowtechlab.org/images/a/ad/Monter_une_Communaut_Locale_Low-tech_Lab_Charter_Signature_EN_.pdf
- The sobriety/sufficiency principle can find an echo in the first of Cramer's 10R principles of Circular Economy. Indeed, the R0 principle simply states "Refuse, because consumers can do without it!".
  - https://en.wikipedia.org/wiki/Circular_economy
- French-speaking learners can also consult the values of Low-Tech as presented in the following video with Corentin de Chatelperron:
  - https://campus.we-explore.org/?CommentFaireMieuxAvecMoinsPenserAutreme

Above: Amin Hasani. person in blue denim jeans holding black and gray corded headphones November 2020. Unsplash. https://unsplash.com/photos/person-in-blue-denim-jeans-holding-black-and-gray-corded-headphones-kSacao6ETQw

6: Technology and Ethics

Some ethical views of technology

In a neutral or instrumental view, technology is seen as mere means to an end, or 'just tools' used to solve problems. As such, it is neither good nor bad a priori; it is the use to which it is put that can be subject of ethical judgment. Therefore, Designers, Engineers and Managers can neither be blamed when it is misused, nor honoured when it is used for good. It is the users who are responsible for its use, good or bad.

The progressive view is based on the utopia of indefinite and favourable improvement. Successive revolutions have been driven by the desire to make human beings ever more autonomous in the face of Nature, or to achieve economic imperatives. And any eventual problems posed by contemporary situation or current technologies will inevitably find a solution in future technologies. So, there can be no question here of criticising technology, since it defines a kind of ethics of progress.

Over time, a critical view has been undermined by the many negative outcomes attributed to the development of technology. And the accumulation of technologies that are supposed to solve previous problems has often failed to live up to its promises. A sort of ethics of caution is emerging here.

An anthropological view states that technology is an essential part of human activities. It therefore affects the way we view nature. On the one hand, technology often finds its source in our admiration for Nature and the prodigious survival dynamics it conceals. On the other hand, technology offers us new ways of relating to and using Nature, often by exploiting its resources. It also transforms our humanity, since human beings can be described as a technological species. But the existence of a given technology can limit our ability to invent new responses that are more appropriate and more respectful of a new problem or context.

Finally, a symbolic view considers that technology is an integral part of the history of human civilization, and that it constitutes a heritage that we inherit. Therefore, it is a legacy that calls into question its accessibility to all human beings. In some sense, this opens the question of Open Source and Open Design.

Value alignment of technology

As an instrumental value (a means of achieving another value), technology must contribute to positive ends and avoid contributing to negative outcomes. For positive outcomes, we can ask for reliability and resilience. As far as negative outcomes are concerned, the principle is to minimise the risks, either by reducing the probability of their occurrence or by reducing their actual impact. When considering the negative effects of a technology, all human groups must be considered separately. Since some could be systematically negatively impacted, it is not enough for a technology to be acceptable on average: it has to be acceptable to everyone.

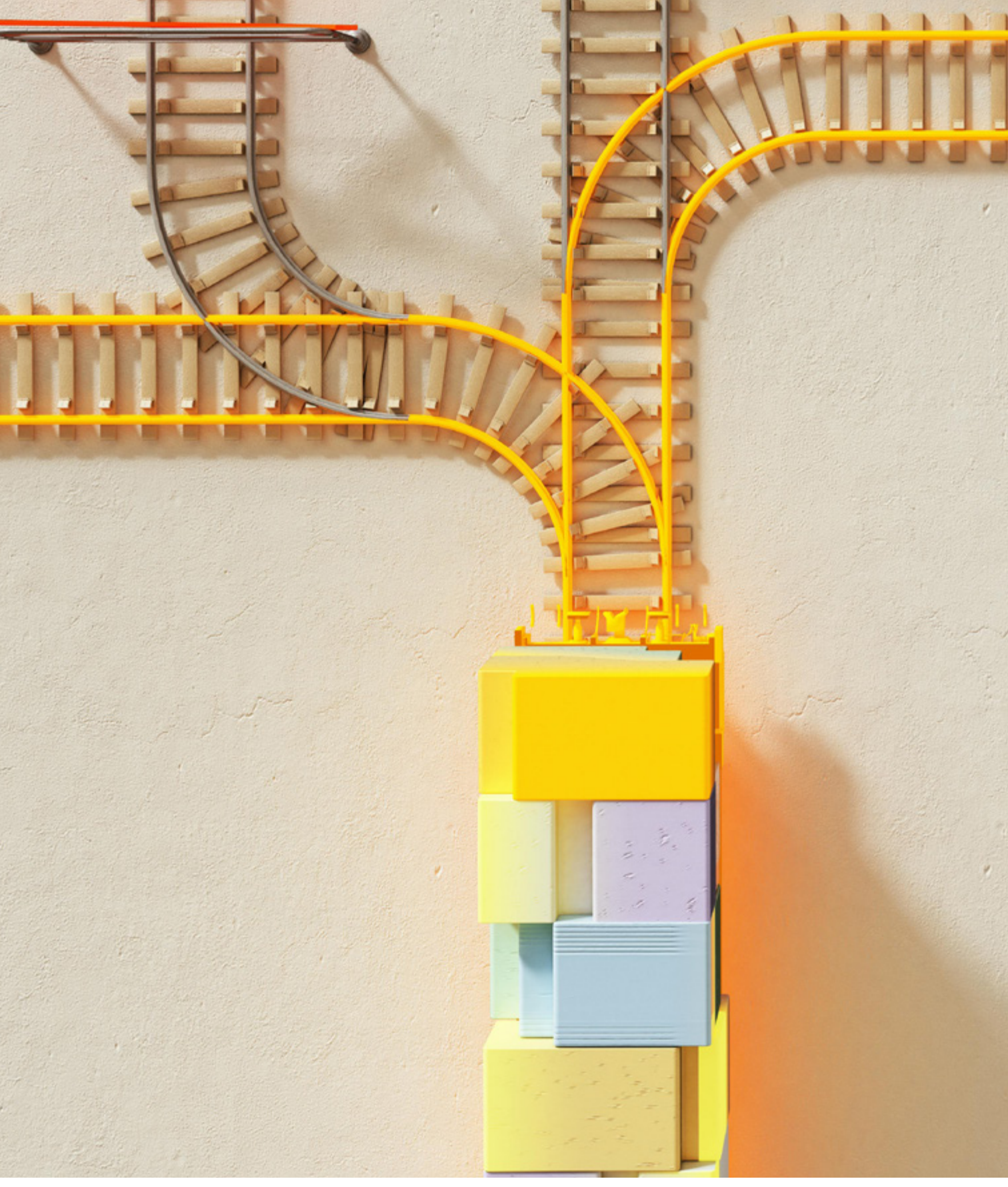
As an intrinsic value (a value in itself), technology becomes a capability of the human beings, rather than a simple toolbox. The focus will then be more on the actual way in which the technology works than on its results. Indeed, elegance, coherence, simplicity... are expression of beauty, even for technology. As a human capability or legacy, technology must not compete with other human values: democracy, autonomy, etc. Finally, we must avoid passing on technologies that are intrinsically evil as part of the human heritage.

Ethical by Design

The "Ethical by Design" mindset integrates ethics as an essential constituent of the Design process. It ensures that ethical issues, principles, and values are considered from the beginning and through the whole process. It also seeks to promote collaboration and innovation in ecosystems, instead of isolated companies. Among many others, we can note the "Value Sensitive Design" methodology, as well as the Responsible Research and Innovation (RRI) concept developed as a process implying societal actors and innovators in a mutual responsibility with respect to ethics and sustainability.

Links to other content in the Book:
Open Design (p. 95)
The Three R's (p. 111)

References and Further Reading:
[4.] B. Friedman and D. G. Hendry (2019), Value Sensitive Design : shaping technology with moral imagination, MIT Press.



Above: Google DeepMind. An artist's illustration of artificial intelligence (AI). July 2023. Google DeepMind. Pexels. https://www.pexels.com/photo/an-artist-s-illustration-of-artificial-intelligence-ai-this-image-depicts-ai-safety-research-to-prevent-its-misuse-and-encourage-beneficial-uses-it-was-created-by-khyati-trehan-as-part-17485633/

Class Activities

After presenting the contents of this Class, it may be interesting to invite teams of learners to consider one given technology and to evaluate it with respect to ethical issues. They can look for elements in favour or in disfavour of this technology, either from the ethical approaches discussed in Classes 2 et 3, or from the specific issues of current Class. The online tool Kialo (see Resources) enables arguments to be recorded efficiently, collaboratively, and progressively,

- An existing technology that generally stimulates discussion is the guillotine. Although deeply rooted in French history, it leaves no one indifferent, whatever their origin.
- One can also consider the invention of the steam engine, with its immediate and positive impacts on mining and on industry, but also with its other impacts on environment and sociology.
- Another technology is that of guns. Learners can be asked to evaluate to what extent do guns transform a man into a gunman.
- A final example is the prolific invention of torture technologies over the centuries. Can we take a neutral view of these technologies? How can they be assessed from an anthropological or symbolic perspective?

Above: Jordan Skattum. Man Forging Metal. October 2019. j.mt_photography Pexels. https://www.pexels.com/photo/man-forging-metal-3680094/

7: Low-tech and similar spirits

A "technological paradigm" delineates the specific requirements to be addressed, the scientific foundations applied, and the materials and technologies utilized within a given context. It is a structured approach to resolving technical and economic challenges by employing carefully chosen scientific principles coupled with defined strategies to develop, protect, or disseminate knowledge. This Class provides selected quotations about different technological paradigms.

Low-Tech

"The issue is not between growth and degrowth, but between endured degrowth – because the question of resources will catch up with us at some point – or chosen degrowth."
Ph. Bihouix (2014), L'âge des low-tech, Seuil, p. 113.

"A technology is low-tech if it constitutes a basic technical element of a sustainable, equitable and convivial society."
J Carrey, S. Lachaize and G. Carbou, Les low-techs comme objet de recherche scientifique. Vers une société pérenne, équitable et conviviale. Online : https://lapenseeecologique.com/6312-2/

"Without a social, cultural and politicised low-tech approach, low-tech will not contribute to a technical democracy, and without bodies for the democratic deliberation of our socio-technical and socio-economic choices, low-tech risks not achieving its systemic, cultural and social dimension".
Q. Mateus and G. Roussilhe (2023), Perspectives Low-Tech. Editions divergences.

Convivial Tech

"A convivial society should be designed to allow all its members the most autonomous action by means of tools least controlled by others."

"An individual relates himself in action to his society through the use of tools that he actively masters, or by which he is passively acted upon. To the degree that he masters his tools, he can invest the world with his meaning; to the degree that he is mastered by his tools, the shape of the tool determines his own self-image.

Convivial tools are those which give each person who uses them the greatest opportunity to enrich the environment with the fruits of his or her vision. Industrial tools deny this possibility to those who use them and they allow their designers to determine the meaning and expectations of others. Most tools today cannot be used in a convivial fashion."

"The future depends more upon our choice of institutions which support a life of action than on our developing new ideologies and technologies."
I. D. Illich (1977), Tools for Conviviality.

Frugal innovation / engineering

"There is more to this than simply cutting costs to the bone. Frugal products need to be tough and easy to use. [...] Frugal innovation is not just about redesigning products; it involves rethinking entire production processes and business models."
The Economist (2010), First break all the rules: the charms of frugal innovation, The Economist, 15 April, available at: www.economist.com/node/15879359

"Frugality was a virtue of the ancient world when economic resources were deficient, and is equally relevant to most of today's emerging economies where similar conditions exist."

"[Frugal innovation is] meeting the desired objective with a good-enough, economical means. [...] At the basic level, frugal innovation could be thought of as a "mindset", or a "way of life". At an activity level, it could be construed as a "process" or a "workflow", and finally, the "outcome" could be manifested as a product or a service."
P. Soni and R.T. Krishnan (2014). Frugal innovation: aligning theory, practice, and public policy. Journal of Indian Business Research, 6(1), 29–47.

Above: Quang Nguyen Vinh. Asian boy helping grandfather to make bird cages. February 2021. Pexels https://www.pexels.com/photo/asian-boy-helping-grandfather-to-make-bird-cages-6712948/

7: Low-Tech and similar spirits

Design Thinking, Human Centred Design

"It's not 'us versus them' or even 'us on behalf of them.' For a design thinker it has to be 'us with them'."
Tim Brown, CEO and President of IDEO

"We spend a lot of time designing the bridge, but not enough time thinking about the people who are crossing it."
Dr. Prabhjot Singh, Director of Systems Design at the Earth Institute

"We must design for the way people behave, not for how we would wish them to behave."
Donald A. Norman, Living With Complexity

Simplicity

"Any intelligent fool can make things bigger and more complex. It takes a touch of genius - and a lot of courage - to move in the opposite direction."
E. F. Schumacher (1973), Small is Beautiful, in The Radical Humanist: volume 37, p. 22

Small is Beautiful
E. F. Schumacher (1973), Small is Beautiful : a study of economics as if people mattered, Blond and Briggs. Available online : https://www.ditext.com/schumacher/small/small.html

The KISS principle: keep it simple, stupid.

Happy sobriety

"Sobriety is a happy option that produces a lighter, calmer and freer life. Happiness is not in possessing, in having, but in being."

"True power lies in the capacity of a human community to be content with little but to produce joy."

"It is in today's utopias that tomorrow's solutions lie."

Class Activities

To better appreciate the quotations of current Class, learners can be asked to write a personal essay on their motivations for adhering to one or other approach, with a view to convince other learners. Of course, they should first look for additional insights and motivations by browsing literature, websites, and so on. For example, the website of the Low-Tech lab: https://lowtechlab.org/en/low-techs

Such an activity is crucial in the training of designers, engineers, or managers in relation to the Low-Tech approach. Indeed, they will often be asked by their peers to justify adopting an approach that is not "mainstream". They therefore need to develop their argumentation, drawing on a variety of arguments.

The Imperative of Responsibility

An ethical workshop

Worksheet 1

Ethical Product Design Canvas

Our Design Goal:

WE WANT TO...	BY DOING...	IN ORDER TO...

With specific stakeholders (think inclusively!) in a clearly identified territory (geographically, in terms of tangible or intangible resources...)

Ethical Assessment

Virtue Ethics

"An action is morally right just because it would be done by a virtuous person acting in character"

- Is your design morally right? Why (not)?
- How could you change that ?

Ways for Improvements:

- Which virtues could your design affect? Positively or negatively?
- How could your design stimulate virtuous behaviour and commitment to human flourishing?
- How could your design help to perceive the interpersonal links?
- How could your design encourage personal experiences and self-reflection?
- What kind of person does your design appeal to?
- Is your design inclusive, with the mindset of attentiveness to each individual stakeholder?

Deontologism

"An action is morally right just because it abides moral rules and serves a person's moral duty"

- Is your design morally right? Why (not)?
- How could you change that ?

- What would the world be like if everyone uses your design?
- Would you use your design?
- Would you let your children know and use your design?
- In your design, do you treat people with respect and not solely as a mean to achieve a goal?
- In your design, do you treat the human community with respect and not solely as a mean to achieve a goal?
- In your design, do you treat Nature with respect and not solely as a mean to achieve a goal?
- Would your design improve people's expertise, with a view to passing on the legacy to future generations?

Consequentialism

"An action is morally right just because it produces the best actual or expected results for the most people"

- Is your design morally right? Why (not)?
- How could you change that ?

- What are the consequences of your design for the different stakeholders and for the territory's resources?
- Could your design bring the greatest happiness to the greatest number?
- Can you include corrective responsiveness to observed negative effects?
- Could you improve the consequences for the least satisfied stakeholder? Or the least well impacted? Or to the weakest stakeholder?
- Does your design preserve or enhance the potential for future generations to live at least as well as the current one?

Care Ethics

"An action is morally right just because it would be done by an altruistic and self-denial person"

- Is your design morally right? Why (not)?
- How could you change that ?

Ubuntu Ethics

"An action is morally right just because it respects human dignity and serves the human community in harmony with Nature"

- Is your design morally right? Why (not)?
- How could you change that ?

Responsibility Ethics

"An action is morally right just because it produces the best results for the permanence of genuine human life on Earth"

- Is your design morally right? Why (not)?
- How could you change that ?

Download Worksheet from DOI: 10.5281/zenodo.14621500

8: An ethical workshop

Investigating an emerging technological paradigm

The Low-Tech approach can be considered as an emerging technological paradigm. On the one hand, it advocates technological sobriety, which can make use of pre-existing levels of technology. On the other hand, such a recourse is not usual in our contemporary society. It is, therefore, difficult to identify the values, principles or virtues that will be called upon today and in the future.

The learner's team carrying out this workshop should choose a technological concept to study and may consider itself as the design team for this concept. They can study either a technological paradigm (for example, the Low-Tech approach) or a specific product/service/system (for example, the Norwegian Pot). Then, they can carry out the "TimeLines" activity to first identify ethical issues related to the chosen concept, using a collective intelligence process. It can be interesting to run this activity with several different panels, to enrich the results. The ethical issues obtained in such a way will have greater credibility.

Finally, they use the "Ethical Product Design Canvas" to formalise the outputs of the workshop as well as to imagine ethical improvements of the technological concept.

TimeLines

The "TimeLines"[5] activity aims to identify the potential ethical issues of emerging technology. It can be described in 7 steps:

1. Gather a diverse panel of participants and establish a climate for collaborative design. Here, the panel members must specifically perceive or represent the territory's resources (tangible or intangible).
2. Propose the technological concept to be studied. Let the panel name the concept.
3. Invite the panel members to list the various stakeholders who are or could be involved in the specific territory, in an inclusive mindset. The aim here is to draw up an initial list, which can obviously be expanded upon at subsequent stages if needed.
4. In a brainstorming phase, the participants write on sticky notes news headlines of articles that could be written in the future in relation to the chosen technological concept.
5. The participants then place their news headlines on timelines to the right of a central sticky note with the concept name. This stage makes it possible to co-construct different future scenarios, ranging from the most utopian to the most dystopian.
6. In a second brainstorming phase, the participants consider the previously identified stakeholders and compose messages they could post on social networks to express their feelings (positive or negative) about events of the various scenarios.
7. In a final collective analysis and discussion phase, the panel members highlight the (positive or negative) risks and the values, principles and virtues revealed in these posts. They can also state a hierarchy between those ethical issues.

Ethical Product Design Canvas

Several canvases can now be used to support thinking and/or communicate ideation results in many fields. Instead of seeing them as frameworks that restrict creativity, we can see them as a set of good questions to help ideas evolve positively.

Here, we propose to use an extended version of the Normative Design Scheme[6], complementing it with the abovementioned contemporary ethical approaches. Therefore, this Ethical Product Design Canvas is a novel tool aimed at ethically improving the technological concept under study.

First, the design team is invited to complete its objective by describing its intention, its technological concept and the expected outcomes. The intention is a kind of vision of what the beneficiaries will be able to experience. The concept is the type of product or technology being considered. As for the outcomes, these need to be seen in the context of sustainable development.

These three elements are part of a well-defined context. The design does not necessarily aim to determine a universal solution that could be applied without any nuance everywhere on the planet. On the contrary, defining the design context as a framework for reflection is generally more appropriate. It is therefore necessary to identify, on the one hand, the stakeholders in a broadly inclusive mindset and, on the other hand, the territory's resources (tangible and intangible). Among the resources, one can also consider the existing ecosystems that can support the design.

In the second step, the design team assesses ethically its design project with respect to the 6 recommended ethical approaches: virtue ethics, deontologism, consequentialism, Care Ethics, Ubuntu ethics and Responsibility ethics. The "TimeLines" activity results can enrich the ethical reflection by drawing attention to values, risks or virtues that need to be specifically considered. The aim of this stage is to highlight areas for essential development.

Finally, based on this assessment, the design team can imagine ways to improve the concept. Whilst improvement is generally considered with respect to technical or economic issues, the focus is set on ethical improvements. The ethical frameworks inspire the questions driving the proposed brainstorming stage.

Depending on the circumstances, several iterations may be necessary.

References and Further Reading:

[5.] Richmond Y. Wong and Tonya Nguyen. 2021. Timelines: A World-Building Activity for Values Advocacy. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21). Association for Computing Machinery, New York, NY, USA, Article 616, 1–15. https://doi.org/10.1145/3411764.3445447

[6.] Ethics for Designers — Normative Design Scheme tool. (n.d.). Ethics for Designers. https://www.ethicsfordesigners.com/normative-design-scheme

Above: Masjid Pogung Dalangan. Young man reading book near river. December 2021. Unsplash. https://unsplash.com/photos/a-man-sitting-in-the-grass-reading-a-book-c56M5emNMKU

9: References and Resources

Books

+ Michel Métayer and Guy Ferland (2021), Philosophie éthique (5e ed), Pearson ERPI.
+ Sven Nyholm (2023), This is Technology Ethics, an introduction, Wiley Blackwell.
+ Ibo Van De Poel and Lambèr Royakkers (2011), Ethics, Technology and Engineering, an introduction, Wiley-Blackwell.

Kialo

Practically, if you are considering organising such a course as The Imperative of Responsibility it may be worth considering the www.kialo-edu.com website.

It enables ethical debates to be conducted by means of a written exchange of arguments for or against an ethical position, with a structured organisation of these arguments. The advantage of such a tool is that it gives equal space to extroverted and introverted students, and both to face-to-face and distance learning students.

Contributions can be made anonymous and the debate can be organised synchronously or asynchronously. After a debate, it is useful to review the arguments to identify which ethical families they can be associated with.

SEP

The Stanford Encyclopedia of Philosophy consists of the plato.stanford.edu website. It offers up-to-date references on numerous items related to the subject of this chapter. For example, on Paul Ricoeur, Emmanuel Levinas, consequentialism, deontologism, virtue ethics, and so on.

Promethee Challenge

A hackathon-type module on engineering ethics. See the video on https://videos.univ-grenoble-alpes.fr/video/24604-kaleidoscope-challenge-promothee/ or consult the book https://www.thebookedition.com/fr/challenge-promethee-p-393165.html.

Ethical tools for designers

Provide efficient templates to ethically consider and conduct a design process. Templates are scheduled along the sequential steps: envisioning, framing, creating, realising, and validating. See https://www.ethicsfordesigners.com/tools

Enseigner l'éthique

A French-speaking website for the teachers interested in teaching ethics:

https://www.enseignerlethique.be/ It proposes conceptual cards, case studies and various resources.

OTL

The Open Textbook Library (https://open.umn.edu/opentextbooks) proposes courses on various domains. We can mention Business Ethics, Ethics for A-Level, and Responsible Innovation.

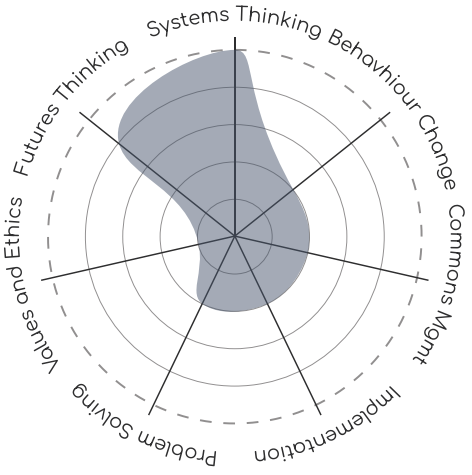
Low-Tech Entrepreneurship

Loann Astorino, Sébastien Bette, Philippe Fortemps, Fabian Lecron,
Gauthier Renard, Virginie Vandenbulcke

6 lessons
1 Training Workshop

Above: Enes Çimen. Man selling handmnade wooden cutlery. July 2022. Pexels. https://www.pexels.com/photo/man-selling-handmade-wooden-cutlery-10204219/

Low-Tech Entrepreneurship



Learning Hours		
To succesfully complete this module the learner will engage in:		
Activity	Activity Description	Hours
Lecture	Online or in-person instruction in the module contents	12
Self Directed	Individual Assignment (2 individual essays) Group Assignment & Final Presentation	18

Module Objectives

In today's evolving business landscape, entrepreneurship now focuses on sustainable, accessible, and practical innovation. Low-Tech entrepreneurship emphasises simple yet effective solutions to complex challenges, highlighting efficiency, affordability, and environmental awareness as alternatives to resource-intensive methods.

This module explores Low-Tech entrepreneurship through key management pillars: organisation strategy, marketing, financial models, etc. By aligning entrepreneurial efforts with these principles, businesses can navigate uncertainties and promote resilience for long-term growth.

This course module utilises models for inspiration, process, and support.

The present module consists of six lessons providing successive insights into Low-Tech entrepreneurship. It is supplemented by a description of a workshop that gathers all these insights around a case study. Therefore, several approaches can be considered for delivering this module to learners. One approach is to first present the six content lessons and conclude with the case study. Another approach is to conduct the case study with learners and gradually introduce the contents as needed.

Learning Outcomes

1. Learn the essential component of planning a new start-up
2. Recognizing viable market opportunities
3. Customer discovery via primary market research
4. Creating a business model
5. Developing financial strategy
6. Identify today's social challenges involving ethics, social Responsibility and sustainability
7. Integrate creative business strategies with engineering and effectively work in multi-disciplinary teams
8. Make decisions in highly uncertain and unstructured environments, and take in feedback from a large variety of sources that use it to improve their business plans, or help them to 'pivot' and find alternative ideas or approaches.

Above: Pixabay. Person in Black Shirt Holding Glass Rod. October 2016. Pexels. https://www.pexels.com/photo/person-in-black-shirt-holding-glass-rod-220990/

1: The paradox of Low-Tech entrepreneurship

Low-Tech, often seen as inherently virtuous, has the potential to disrupt the status quo and convey its societal vision more effectively on a larger scale. To champion its social and environmental virtues (sobriety, accessibility, sustainability), it must transition from a small-scale operation to a more robust, entrepreneurial endeavour. This concept of 'Low-Tech entrepreneurship' may initially seem contradictory, but it promises to reshape our understanding of business and sustainability.

Current entrepreneurship is not compatible with the Low-Tech mindset

Current entrepreneurship, often associated with a relentless pursuit of financial gain, is deeply intertwined with a narrative of proletarianisation and casualisation (uberisation). Fueled by short-term profitability and the illusion of boundless growth, this narrative is perpetuated by mechanisms like patent systems that disproportionately benefit a select few. Globalisation further exacerbates this trend, enabling the seamless flow of products and commercial exchanges. In stark contrast, Low-Tech entrepreneurship emerges as a beacon of change, advocating for sustainability and resource conservation.

Today, businesses are often steered by financiers fixated solely on maximising profits, perpetuating a cycle of planned obsolescence—be it physical degradation or psychological manipulation—that artificially sustains a perpetual demand for new, often superfluous, products.

In contrast to this paradigm, Low-Tech emerges as a counterforce, advocating for sustainability and resource conservation. It seeks to mitigate the environmental impact of energy-intensive practices and rampant overconsumption. Moreover, Low-Tech champions the virtues of moderation, prompting a re-evaluation of needs at the individual consumer level and within broader societal frameworks. By prioritising accessibility, Low-Tech endeavours to empower individuals to craft, modify, and repair their possessions, thus fostering a culture of self-sufficiency and promoting a more equitable distribution of technological abilities. Embracing a localised approach, Low-Tech underscores the importance of addressing local needs with local resources, envisioning territories not merely as geographical entities but as vibrant ecosystems intertwined with the lives of their inhabitants.

The Low-Tech mindset cannot spread without entrepreneurial support

Low-Tech relies on the reclamation, reuse, or recycling of waste materials. However, managing the quantity and quality of these waste streams proves challenging on a smaller scale. Operating on a small scale does not achieve real and lasting effectiveness. Low-tech strives for individual autonomy. Yet, the need to acquire effective tools or the necessity to master their usage may impede accessibility. Not everyone can become an expert in all facets of their life without compromising the quality of the devices produced. Additionally, physical, cognitive, or professional impairments may prevent individuals from achieving the same level of expertise. The underlying ableist assumption of empowerment can contradict the values of mutual aid and solidarity.

Low-Tech appears to endorse an artisanal model, requiring the reappropriation of numerous jobs through lengthy apprenticeships, often with uncertain levels of safety or performance. There's a necessity for devices to be sufficiently optimized to avoid generating more negative impacts than positive ones and to be devoid of hazards (such as cuts or burns) for both makers and users. Standardized Low-Tech solutions are needed to facilitate their dissemination. Indeed, it makes sense to ask Low-Tech tools and products to be reliable, durable, efficient, safe, ergonomic, and relatively consistent across variations.

Reinventing entrepreneurship

A Low-Tech society is a societal project that demands a re-evaluation of the current capitalist model. The low-tech approach advocates systemic change, which entails reconsidering the predominantly economic model of contemporary entrepreneurship. It calls for new Business Model Canvasses (BMCs) that are viable without relying on patents. Indeed, the focus should no longer be on the profit of a few but instead on the well-being of all.

Instead of patents benefiting a select few, knowledge should be open, accessible, and shared. Even if not everyone can construct their equipment, they should at least be able to assemble, repair, and modify their equipment indefinitely using locally produced spare parts. This entails relocating industrial activities. Rather than considering a globalised and uniform market, it also entails a "relocation" of the needs since it addresses identified needs within specific contexts, reinvesting in the local economy through local businesses and factories.

Financing methods should diverge from seeking investors primarily focused on maximising dividends and company profits and instead explore avenues like microfinance and crowdfunding. The Social and Solidarity Economy dimension underscores principles of equity and justice. It may serve as a vehicle for education and empowerment, emphasising not just selling pre-packaged solutions but teaching how to construct locally adapted ones. Moreover, Low-Tech entrepreneurship should transcend individual ventures, fostering the growth of innovative Low-Tech ecosystems in a Circular Economy mindset.

Therefore, reinventing entrepreneurship is indispensable for a smooth and effective ecological, social, and societal transition.

Above: LowTech Lab. Organize a Low-Tech camp IMG 6058. December 2021.
https://wiki.lowtechlab.org/w/index.php?curid=61045

2: Strategy and Economic Models

Sustainable entrepreneurship goes beyond the simple pursuit of profit. It recognizes that the planet's resources are finite and that entrepreneurs must consider the social and environmental impact of their activities and act for the common good. This means designing products and services that have a positive impact on the environment and society. To achieve this, we need to adopt new strategies that integrate social and environmental responsibility into traditional business models. We need to move towards sustainable business.

Committing to a more ethical entrepreneurial activity must be seen as a global approach and a systematic action that needs to be operationalized. There is an essential framework for considering many elements in the context of business activity: the Sustainable Development Goals[1] To simplify these major themes, we propose several strategies for operationalizing a more responsible business model at various levels.

Integrate sustainability into the company's purpose

The first step to creating a sustainable model is to integrate a concrete issue into the company's "reason for being" or purpose. The company's activity could, for example, be "committed to the preservation of ecosystems," "committed to social utility", or "committed to the emergence of new behaviours and values". Incorporating a superordinate focus into the objectives will help give meaning to the company's actions. This thematic focus should be helped by a well-documented manifesto setting out the means to achieve it. For example, to over-compensate our impact on biodiversity, to have a measurable positive impact on the common good, or to choose our suppliers in line with our purpose.

Integrate a sustainable field of activity

Another lever for building sustainable entrepreneurship is generating activity in an already sustainable field. For example, areas of the circular economy such as recycling, reuse, or repair. Note that in this framework, less sustainable areas of activity can have subsectors that are sustainable. For example, peasantry is the subfield of "agriculture and agri-food." We, therefore, need to consider the sustainability and equity of the company's area of activity.

Question the existence of the product itself

Is my product useful? Does it address an existing problem? Is the problem caused by factors that can be resolved? Is it caused by a sustainable activity? What impact will my product generate? By systematically questioning the principle of your product, you can create a solution that won't "continue to keep". This approach aims to address high-level questions in product design. To take all these factors into account, we can look at notions such as technological solutionism: the belief that machines can solve the problems created by other technological solutions (e.g. building a new machine to eliminate Nespresso coffee capsules), or rebound effects: the increase in consumption resulting from the improvement of a technology (e.g. improving telephone batteries, creating applications that consume more energy). Of course, this step can be a real puzzle, but it must be part of the product design strategy.

Integrate constraints into product design

It's essential to establish ethical guidelines during the design phase, including measures such as social integration, product inclusiveness for all populations, and a commitment to creating transparent, readable, and reassuring usage for all while keeping ethical values and social responsibility in mind. This also means considering the potential impact on individuals, privacy, communities, and society. To implement these concepts, users must be at the centre of the design process and work within their constraints. Co-designers must question the product's usefulness and usability and observe its use. Several actions can encourage this co-design, such as including users in the strategic management of the product, integrating a wide range of audiences, real-life testing, and user dissemination.

Plan optimisations into your strategy

However resilient and entrepreneurial activity may be, by default, it has a negative impact on the environment. Once the business has been launched, it needs quantitative methods to measure and remedy its impact. This can be done by offsetting CO_2 emissions, extending the lifespan of digital equipment, carrying out life cycle analyses on hardware, or by using any of the tools (e.g. the GR491 handbook[2]) at its disposal to implement a strategy for reducing its impact. This strategy must be supported by the operationalisation and monitoring of indicators within the company.

Degrowth as a Global Driver

Finally, all these actions must be considered globally, whether intrinsic or extrinsic to the company model. They must be monitored by indicators and corporate strategies. They must also be considered in a global ideology whose objective is so-called "sustainable" degrowth—in other words, to succeed in building an economic model in a sober civilisation.

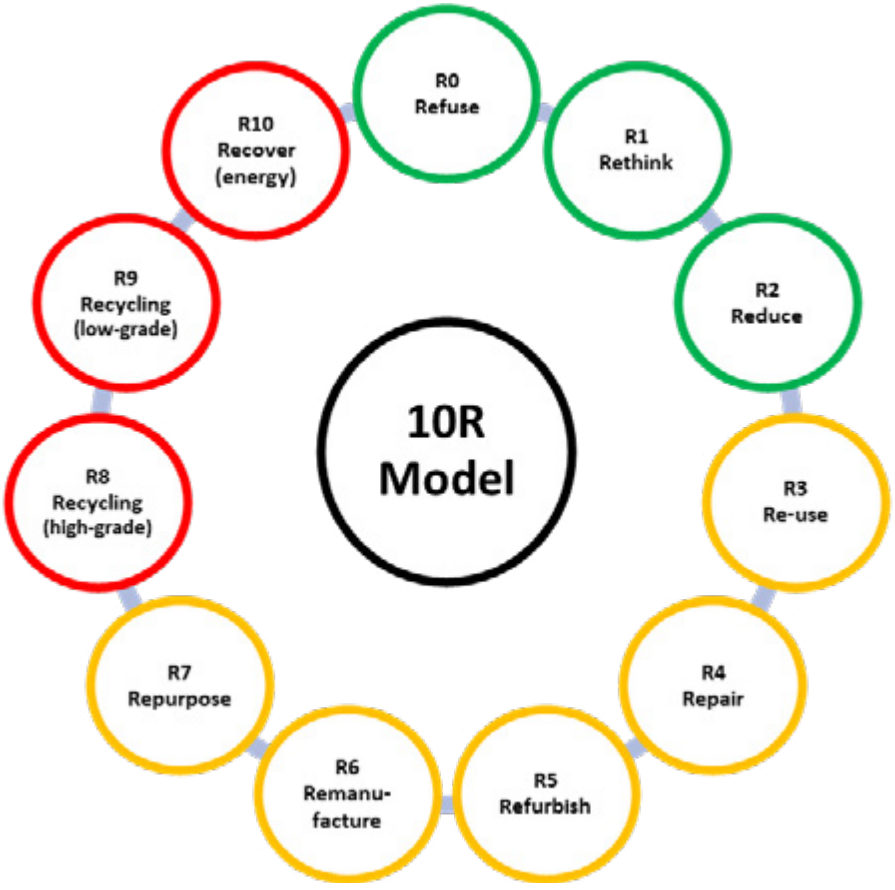
Achieving a sober and positive economic model does not necessarily mean no asset exchange is possible. Finding the right economic model can create many new opportunities. In recent years, green tech and its derivatives (cleantech, climate tech, etc.) have been very popular and are one of the fastest-growing sectors in terms of employment. These companies respond to market logic and are not ecological or sustainable. They do, however, show that a market exists.

Making resilience part of your strategy means limiting product risks by asking good questions related to concrete goals. It means optimising it by considering users as partners. It also means implementing actions that unify and differentiate by creating a positive brand image. Finally, it may be a way of finding a real meaning.

References and Further Reading:

[1.] Note that there is also a tool that allows you to create your business model based on these objectives: The SDGs and the business model canvas: https://sdgs-entreprise.be/business-model-canvas-durable/.

[2.] The GR491 Handbook https://gr491.isit-europe.org/en/



Model of Circular Economy, adapted from J.Potting et al (2017), Circular Economy: Measuring Innovaiton in the Product Chain, PBL - Netherlands Environmental Assessment Agency. Recycling has been split into high grade and low grade.

3: Emerging economic models

In a world of constant evolution, more and more voices are rising to question traditional economic models, often focused on infinite growth and profit maximisation. Instead, alternatives are emerging, offering fresh perspectives on organising our economy to better serve individuals and the planet.

Circular Economy

The circular economy, a significant player among these emerging economic models, starkly contrasts the linear "take, make, dispose" model. It champions reuse, recycling, and regeneration of resources, aiming to eradicate waste and establish a system where products and materials are in a perpetual cycle of reuse, repair, and recycling.

The 10R model is a tool used to combat planned obsolescence. The model can be grouped into three domains:

- During design and production, the approach first involves questioning the relevance of the need with a mindset of reasonable consumption (consumers are encouraged to make conscious choices). Then, the eco-design should consider maintenance, repairability, and total or partial reuse of product components from the outset. This concerns product/service configuration, production methods, material choices, and efficient use of resources.
- During usage, the circular economy emphasises efficiency, repairability, and reuse to extend the lifespan of objects while preserving or even improving their quality of use over time (for example, by hardware remanufacturing or software reconfiguration of the objects).
- After a use, efforts should focus on reusing products, components, or materials. This can lead to very different uses from the initial one. Energy recovery through combustion is the last resort to consider.

An interesting application lies in transforming waste into a source of materials for other contexts, for instance, converting plastic waste into bricks that are more durable than concrete (e.g. https://www.gjenge.co.ke/).

3.2. Collaborative Economy

Collaborative economy, also known as the commons economy, is based on resource sharing and cooperation among individuals. It fosters the creation of collaborative goods and services, where people share, exchange, and collaborate to meet their needs more effectively and sustainably.

While the consumption economy is a possession economy, where everyone must own the goods they want to use, even if only temporarily, the collaborative economy encourages the shared use of these goods.

For example, almost every household owns a drill, yet it's only used for a few hours a year. Sharing a drill within a neighbourhood would provide access to an arguably more efficient tool at a lower cost with a much reduced environmental impact.

In this context, individuals can become service providers by sharing their resources, skills, and time. Digital platforms can facilitate the connection between users and providers, but there are also more simple mechanisms. This can be seen as favouring a local economy, as it relies somewhat on bartering (products, services, knowledge) among neighbours.

The dynamics of Repair Cafés align with the dual perspective of a circular economy (through the repair dimension) and a collaborative economy (through social connections). These workshops are dedicated to repairing everyday objects and are organised locally, bringing together people who live or frequent the same area. They also operate on the basis of "commoning" the tools, spaces, knowledge, and skills.

In addition to the economic and environmental benefits, such an economy fosters social bonds by bringing together various stakeholders, encouraging them to meet, share, and trust each other.

Functionality Economy

Functionality economy, or product-service system, emphasises the provision of services rather than simply selling products. Instead of owning goods, consumers pay for access to their functionalities, encouraging businesses to design durable products and maximise their lifespan.

The economy of functionality replaces the traditional model of selling goods with a focus on selling the usage of those goods. Instead of owning a product outright, customers pay for its use over time. This shift is exemplified by the transition from personal car ownership to on-demand services like car rentals and ride-sharing.

Manufacturing companies are adapting their offerings to align with this approach. By partnering with service providers, they create high-value usage experiences while minimising the reliance on physical resources. Importantly, the service provider retains ownership of the product and its equipment, incentivising better design, maintenance, and extended product lifecycles.

The territorial perspective plays a crucial role in the development of the economy of functionality. Understanding the local context allows businesses to customise their offerings to meet the specific needs and limitations of the area. For instance, a service-oriented approach might vary between urban and rural settings. Therefore, manufacturers must partner with local service providers to create integrated solutions that benefit both parties. Indeed, the knowledge of a specific territory (with its cultural preferences, language, and lifestyle factors...) can help to best design and market the service. It also prioritises long-term partnerships relying on trust.

An example of a large company is Michelin, which encountered

Above: Steve Knight. MMJ410 1954 AEC Mammoth Major 8 Mk111 - Michelin. August 2020. Flickr. https://www.flickr.com/photos/kitmasterbloke/50229854957/

significant challenges in getting technical advancements with positive environmental impacts (such as an 11% reduction in fuel consumption for trucks) but with higher prices. Michelin no longer sells these tyres, but rather the miles travelled. Additionally, the company manages the entire lifecycle (including inflation, driving advice, retreading, etc.).

Social and Solidarity Economy

Social and solidarity economies favour non-profit businesses and cooperatives, focusing on the values of solidarity, inclusion, and sustainability. They seek to promote local development and strengthen community ties by encouraging citizen participation in the economy.

Indeed, through a holistic approach, social and solidarity economy enterprises aim to place humans at the heart of their projects. Four principles characterise them:

- The purpose of providing services to the community
- Management autonomy to break away from dependence on public authorities
- A governance model by members based on democratic functioning independent of the capital each holds through the principle of "one member, one vote."
- Primacy of individuals (all stakeholders) and the social purpose.

Profits generated by social and solidarity enterprises are not primarily distributed to their members (unlike associations) but are reinvested to further their economic activity and underlying social purpose. In other words, their business models prioritise long-term sustainability rather than immediate financial profit.

These enterprises often focus on marginalised groups, providing employment opportunities for individuals who might otherwise face exclusion from the labour market. They can also market and sell to less privileged target audiences.

The participatory governance of these enterprises generally makes them more sensitive to Sustainable Development Goals (SDGs), such as eliminating poverty, promoting decent work and economic growth, reducing inequalities, and addressing climate change.

We can think here of Sheltered Workshops or Enterprises, which pursue the dual objective of satisfying their clients, both professionals and individuals and pursuing their social purpose: the employment of people with disabilities.

Reduction Economy

Finally, the reduction economy, or frugal innovation, advocates for a minimalist and efficiency-focused approach to designing and producing goods and services. It encourages optimal use of available resources and the search for simple and low-cost solutions to meet human needs.

The scarcity of resources, whether on a local or global scale, can trigger a new wave of innovation. These will be called "frugal innovations" if they are rooted in simplicity, efficiency, and resource optimisation. Unlike the "do more with more" characterising the current consumption economy, it relies on the "more is less" or "innovating better with less" principle, seeking to address needs with minimal means but preserving the solution quality. It favours the use of local knowledge and simple technologies. Thus, we can highlight three principles:

- Fewer functionalities, leading to a smaller, lighter and less resource-consuming product
- Complexity reduction, leading to a more reliable and easier-to-repair product
- Design simplification will lead to a faster and easier product to manufacture, which a larger group of people will be able to achieve.

The reduction economy also focuses on social equity and inclusive growth: marginalised communities can be empowered by affordably addressing their basic needs. The reduction economy advocates for micro-factories capable of creating simple and locally tailored solutions rather than giant mass-production factories. This leads to a more resilient and agile model, bringing employment closer to the points of consumption.

Often, the reduction economy relies on co-creation processes involving all stakeholders in a social innovation process.

Concluding Takeaway

These alternative models represent innovative ways to rethink our current economic system. They emphasise sustainability, collaboration, inclusion, and efficiency, offering promising perspectives for a more equitable and environmentally friendly economic future. Low-Tech entrepreneurship can draw inspiration from these proposals by intelligently hybridising them. For such an interesting combination, the model of circular planned perennity of Mob-Ion deserves to be considered[3]

References and Further Reading:

[3.] https://www.mob-ion.fr

Above: Eamonn O'Sullivan. Riving wood with a froe. November 2011. Hewn.ie.
https://www.hewn.ie/blog-content/2014/10/29/what-is-green-woodworking

Above: Eamonn O'Sullivan. Shaving with a drawknife and a shaving horse (or coopers mare). November 2014. Hewn.ie.
https://www.hewn.ie/blog-content/2014/10/29/what-is-green-woodworking/

4: Sustainable strategic marketing approach

Low-Tech marketing

Undertaking sustainability in the manner of the Low-Tech approach requires following a process that questions the dominant model. In this regard, Sustainable Marketing proposes a framework that implicitly integrates various characteristics of the Low-Tech approach: usefulness, accessibility, autonomy, sustainability, and locality.

Marketing is often reduced to "communication," or even just "advertising," regarding the company's products or services. However, this aspect is merely the tip of the iceberg, etc. Indeed, "marketing approach," or simply "Marketing," corresponds to a much broader approach, defining the guiding principle of the company's overall strategy. In this sense, Marketing involves determining the major directions regarding the products and services to be developed or offered, identifying markets to cover and reach, setting prices, choosing means of product distribution, designing products considering the needs and expectations of users, developing the brand, positioning the offer in the market (especially by conveying a set of values representative of the products/services offered, or the underlying company), engaging with customers/users, and finally, gaining visibility through advertising. It is, therefore, a comprehensive approach enabling a company to offer value (through what is called "strategic marketing") and ensuring that they can benefit from it (through what is called "operational marketing"). Sustainable marketing aims to create and offer benefits for all stakeholders; value represents the difference between these benefits and the associated costs. However, value is not a single entity but a plural notion that varies depending on the analytical perspective.

Thus, marketing represents a significant lever to promote sustainable practices and behaviours by precisely offering "sustainable" products and services, products and services that provide real and fair value (in the face of various socio-ecological challenges). This is called "Sustainable Marketing" or "sustainable marketing approach." In this sense, this approach aligns with the Low-Tech approach: indeed, the characteristics of usefulness, accessibility, autonomy, sustainability, and locality advocated by the Low-Tech approach are subtly present in this sustainable marketing approach.

Classes 4 and 5 present (in summary) this comprehensive approach to sustainable marketing, approaching it from its two classic aspects: the "strategic" aspect and the "operational" aspect. Note that the content of these classes is primarily based on Sihem Dekhili-Aurelie and Merle-Adeline Ochs book[4].

Global Framework of integrating socio-ecological issues

Strategic marketing involves defining the strategic framework for creating products/services by the company; in this sense, it corresponds to the fundamental structure upon which the company is built, etc. (with governance, finance, R&D, procurement, logistics, personnel management functions then being organised around this strategy).

The integration of sustainability is present in several interrelated dimensions. We review them successively.

In a sustainability approach, integrating environmental and social issues is at the heart of the strategic approach of the offer. This involves defining objectives and a purpose that goes beyond profit goals and is long-term oriented (concept of strong sustainability).

NB: Ultimately, these objectives will materialise through various dimensions of operational marketing (offer design, pricing, distribution, communication) and by accompanying consumers towards sustainable practices.

CreatingTriple Value - Meeting Needs

The approach's starting point is to simultaneously create/provide value on three dimensions (Triple Value), i.e., value for the consumer, the company, and society at large (referred to as extended value). The latter consists of both value regarding social issues and value regarding environmental issues.

Thus, from a sustainability standpoint, the approach aims to promote sustainable consumption practices: developing ecological products is necessary but not sufficient; they must be accepted by consumers (creating value for them, helping them make choices easier, supporting them in their usage, building new imaginaries conducive to sustainable development).

Providing Value to Society at Large.

In practice, the DONUT Economics model is a relevant framework for identifying various social and environmental needs and addressing them. The tool provides a holistic view of local and global issues that the company must consider to avoid negative impacts (negative externalities) and provide value (positive externalities - regeneration of the planet and human ecosystems), regardless of the value it may bring for itself or the consumer.

Providing Value to the Consumer.

In practice, we can use Max-Neef's theory of needs to return to the fundamental needs of human beings and thus offer value filled with meaning and authenticity (rather than being a company that

References and Further Reading:

[4.] "SUSTAINABLE MARKETING", Sihem Dekhili-Aurelie Merle-Adeline Ochs, Pearson 2021.

Above: Felix Cohen. Coracle!. July 2010. Flickr.
https://www.flickr.com/photos/felix_cohen/4831115623/

contributes to fuelling derived needs and/or creating the need). Moreover, it is important to integrate into this dimension the mechanisms through which the value of sustainability is perceived and thus constructed by consumers. To do this, since value results from a balance between benefits (biospheric and altruistic-social benefits, and egocentric ones) and perceived sacrifices (costs) by consumers, it is necessary to identify these benefits and costs; also, it is important to be aware of the existence of cognitive biases (positive and negative) associated with this sustainability value.

Providing Value to the Company.

To do this, it is necessary to identify the various stakeholders in the company's ecosystem. Primary stakeholders include employees, suppliers, customers, and investors, while secondary stakeholders include competitors, governments, associations, NGOs, etc. Furthermore, environmental and social issues are also stakeholders with which the company must deal. Thus, providing value to the company means identifying how to meet the different needs of the various stakeholders in its ecosystem to ensure the sustainability (longevity) of the company, especially in a context where socio-ecological issues are becoming increasingly pressing (and creating an increasingly volatile world). Various questions arise (non-exhaustively):

- How to ensure employee motivation, fulfil their quest for meaning through work, ...
- How to maintain a lasting brand image towards customers, meet their ecological expectations (without creating distrust), and raise awareness among buyers and users...
- How to ensure lasting collaborations with suppliers, how to ensure alignment of social and ecological values throughout the value chain, how not to be dependent on upstream...
- How to ensure long-term investor commitment, how to reassure financiers/investors regarding potential changes in business models...
- How to anticipate laws and regulations, ...
- How to be responsive to new societal norms driven by lobbyists and influencers, how to respond to union demands...
- How to be resilient to resource reduction, their increasing costs, how to be robust and adapt to climate hazards...
- How to address social pressures related to poverty, employment, health (burnout), education...

A strong lever for integrating these issues is to develop a "cooperation ecosystem," incorporating all stakeholders, especially primary ones: employees, suppliers, funders, and customers. The goal is then to address the question: "How can we co-create value together?" notably by involving customers in the co-creation of the offer (through a Design Thinking approach, for example), suppliers in co-developing privileged and authentic partnerships, funders/shareholders in co-defining the meaning and values associated with the company's activity, and employees in co-designing the company's purpose, its values, and the organisational model allowing them to flourish.

Developing an Offer in Line with this Triple Value.

The goal here is to define the offer by conceptualising it, with the idea of clearly distinguishing the constituent elements of the offer. To do this, it is essential to identify:

- The basic functionality of the product/service.
- Its necessary functionalities.
- Its added functionalities.
- The associated mental association.

This step is crucial, linking the targeted triple value and the materialisation of the offer through the product. This phase will also identify the developed offering model (B2B, B2C, B2G, etc.). This step is also structured to aim for a "sustainable" materialisation during the product design, notably by identifying the essential functions of the accessory functions of the product/service and to start a reflection on product development based on the functionality economy (providing value through the realisation/execution of a function rather than by purchasing a product that will perform this function – see class 3).

Above: Phillip C Read. Human-powered loom. February 2009. Flickr.
https://www.flickr.com/photos/master-phillip/3249782165/in/photolist-eeL1rz-5XaZ1Z-5XfesY-4woSii-5XaZ5c

5: Sustainable operational marketing approach

A fair pricing policy

A significant business challenge is establishing a fair pricing policy within the sustainability framework. Price not only reflects the value of a product but also influences consumer behaviour and affects the brand's market position. In sustainable products, pricing becomes a matter of "justice" aligning with the company's ethical values and responsibility. This perceived cost is to be juxtaposed with the perceived benefits by consumers, whether they are egocentric, altruistic-social, or biospheric.

Determining the right price involves navigating complexities. A low cost can be seen positively, making sustainable offerings more accessible and generating positive emotions among value-conscious consumers. It may help the product spread. However, it also risks undermining the perceived value and quality of the product, leading to consumer distrust and potentially encouraging overconsumption and waste.

Transparency and consistency are crucial in pricing policies. Hidden costs associated with production, consumption, and societal impact must be factored into the price to reflect the actual cost of the offering, following the "polluter pays" principle.

How to implement a fair pricing strategy.

A fair price represents:

- A reasonable and justified amount in the eyes of consumers;
- A price that comprehensively takes into account all costs (economic, environmental, and social) incurred throughout the product's lifecycle;
- A price that ensures value for the consumer and transparency;
- A price that ensures an equitable distribution of costs and profits among all stakeholders in the value chain.

A fair price encompasses two dimensions:

- Justice related to upstream pricing: this dimension is associated with the equitable distribution of costs and profits across the entire chain, from design to distribution, as well as the consideration of hidden costs and the potential reduction of ecological costs through eco-innovation strategies.
- Justice related to downstream pricing: this corresponds to consumers' perception of justice, evaluating whether the price is reasonable, honest, and transparent.

How to promote a fair perception of prices downstream?

To assess the fairness of a price, consumers rely on their past experiences, general beliefs about brand practices, personal conceptions of justice, and the information available at the time of purchase. To promote a fair perception of prices, four mechanisms can be implemented:

- Consider the process of price comparison by consumers and reinforce the product uniqueness;
- Justify prices through a transparent and honest approach to the price-setting process;
- Demonstrate fairness in cost and profit distribution (as in the fair trade principle);
- Remain consistent and transparent in the face of potential price increases to build trust in the brand (Brand Capital).

Furthermore, reactions to unfair pricing can range from mild reactions, such as disappointment or discomfort, to medium reactions, such as complaints or refund requests, to severe reactions, such as permanent brand detachment or call for boycotts.

A good example of a fair pricing strategy is the restaurant Cassonade (in Brussels), where the customer pays for the next diner's meal. You can influence the next person's meal by determining the amount you wish to donate. So, there is also room for innovation here.

Distributing sustainably

Sustainable distribution is vital for providing consumers access to products and services across various channels, such as stores and e-commerce platforms. Distributors act as intermediaries between producers/industries and consumers. To achieve sustainable distribution, efforts are required both upstream, within the value chain, and downstream, at the distributor level.

Acting upstream in the distribution strategy towards distributors.

Upstream in the distribution strategy towards distributors, sustainability is integrated into distribution circuits in three dimensions: distribution format, distribution channel length, and logistics chain.

There are two types of distributors: specialised and generalist. Specialised distributors focus entirely on sustainability and social commitments (including public awareness), while generalist distributors gradually incorporate sustainable offerings in response to their stakeholders' expectations.

Above: Kanahaya Alam. Espadrille making workshop. June 2018. Juta Shoes.
https://the-dots.com/projects/the-big-issue-how-you-can-get-involved-on-social-saturday-245553

Short distribution circuits with fewer intermediaries (no intermediary: farm sales, producer stores; 1 intermediary: local stores the source directly from producers) are often more sustainable due to reduced energy consumption, enhanced social ties, and promoted local economy.

Sustainable logistics aims to reduce the environmental and social impacts of transporting goods, focusing on long-distance routes. Actions are taken at three levels:

- Optimising transportation methods and delivery flows in the producer-to-distributor chain.
- Reducing home delivery failures.
- Minimising consumer travel distances.

Last-mile logistics is crucial, impacting both the environment and the retailer's image. Attention to consumer travel on the purchasing journey is necessary, and collaborative deliveries offer a potential solution. A circular economy approach valorises raw materials, products, and packaging in the return chain, including recycling, repurposing, and redirecting returns to appropriate destinations.

Acting downstream on merchandising and the customer journey

The distributor, whether within physical or virtual retail spaces, can guide choices towards more sustainable consumption through its "merchandising": the selection of offers, the nature of the shopping experience, or waste reduction policies.

Promoting sustainable products involves expanding their availability and guiding consumer choices towards them. This includes broadening the range by offering sustainable options across various product families, increasing sustainable references within categories, and introducing circular economy-based products. Promoting quality items with longer lifespans is crucial, alongside providing services like rental or repair. "Choice editing" limits non-sustainable products, making sustainable options the default choice. This involves removing harmful products or exclusively offering labelled sustainable ones. These strategies aim to make sustainable options more accessible, encouraging environmentally friendly consumption habits.

Making sustainable products accessible throughout the consumer journey involves effective visual communication at the point of sale and interactions with salespersons who act as ambassadors for sustainable practices. Store layout plays a significant role, with sustainable products strategically placed along the customer's path to facilitate choice.

Waste management encompasses three crucial aspects: minimising product waste, cutting down packaging through bulk sales and collecting waste (e.g through deposit systems). Addressing material/product waste is paramount due to its significant environmental, social, and economic implications. Factors contributing to this waste include visible defects and short shelf life. Strategies to tackle these issues involve:

- Selecting the appropriate materials and products to sell.
- Valorising imperfect products.
- Transforming them into usable goods.
- Implementing reduced pricing strategies.

Bulk sales, retailing non-prepackaged products in reusable containers, align with the zero-waste approach. This strategy fosters consumer relationships (creating proximity/loyalty bonds), reduces waste by allowing customers to purchase the correct quantity, and minimises environmental impact by slashing individual packaging. Implementing bulk sales necessitates adjustments in logistics (transport, stock...), hygiene management, store layout, communication, and staffing.

When either the product itself or its packaging is returned, it helps to reduce the waste effectively and to source new materials in a circular or Low-Tech mindset. Indeed, waste can become the essential raw material for creating new products, especially in a low-tech mindset. Various mechanisms can be implemented to establish this feedback loop from customers. One of them is a deposit system, where part of the product's price paid by the consumer is refunded when:

- Returning the product (e.g., 1083's Infinite Jean reimburses €20 when the jeans are returned to transform them into yarn for another pair of jeans);
- Returning the packaging (bottle deposits, etc.). However, this is associated with three key constraints: optimising return flows, developing more durable containers (eco-design), and the capacity and motivation of consumers to return consigned products.

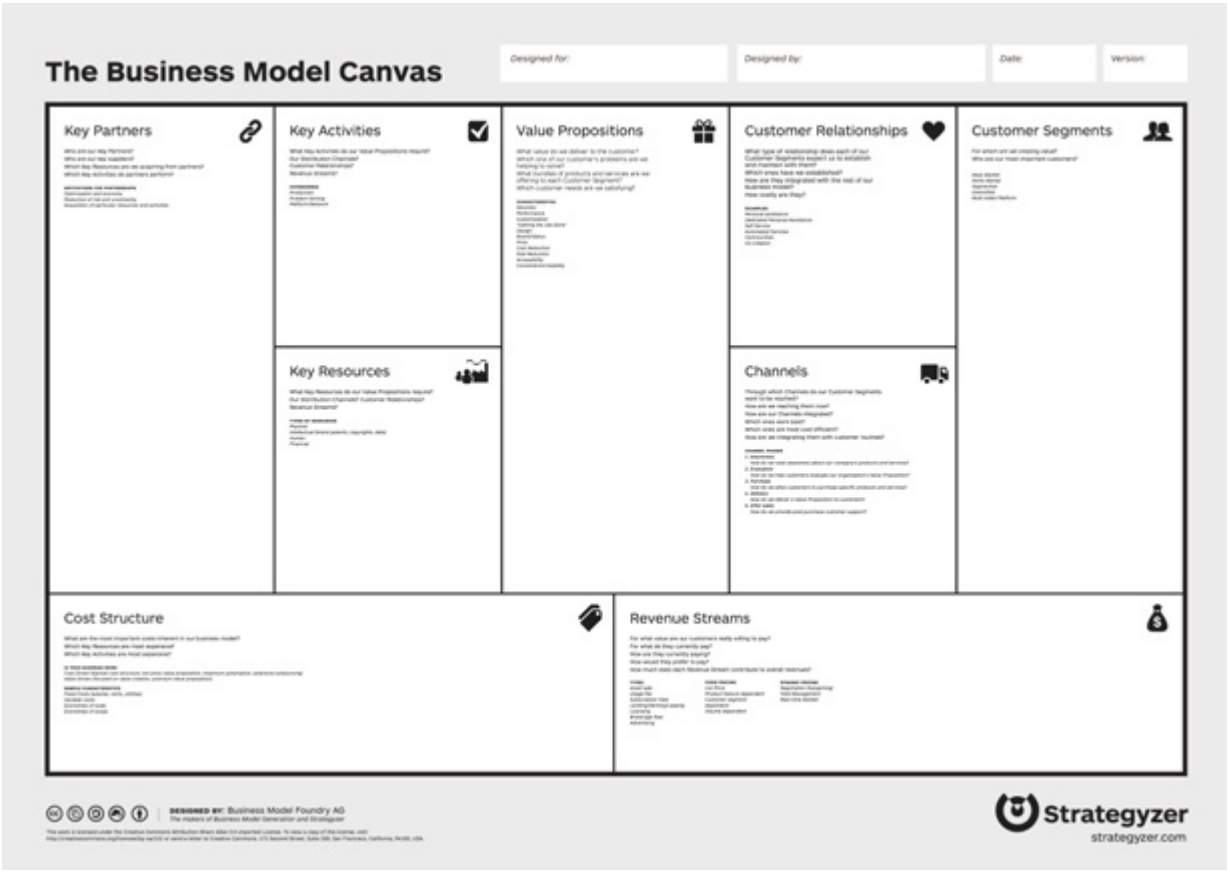
5.3. Branding

Creating a brand for an offer aligned with Triple Value involves several key steps to ensure its success in the market. These elements work together to establish a strong brand presence and effectively communicate consumers' values associated with the sustainable offer.

Before materialising the offer with a product/service, it is necessary to establish a brand identity. The brand name, slogan, and logo will be defined in this phase. The objective is gradually building brand capital, notably by associating it with conveyed values.

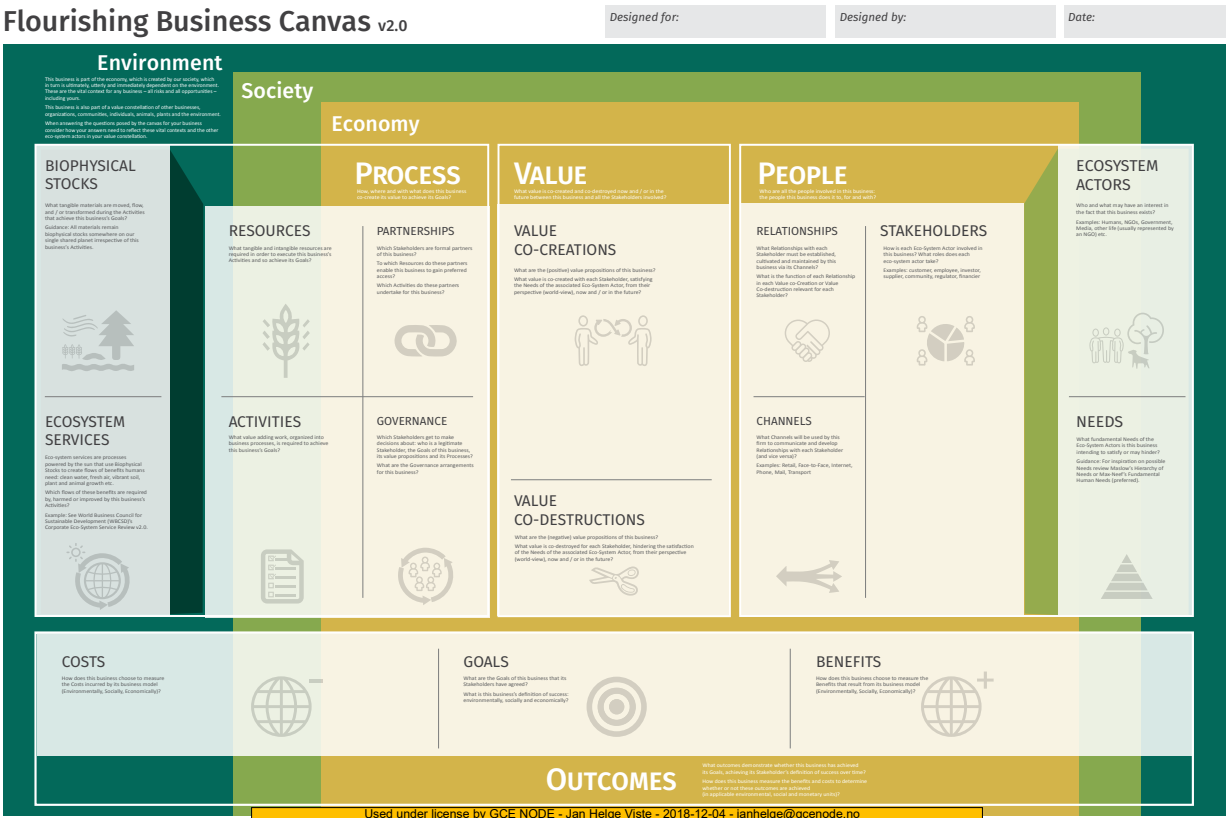
However, defining the company's or brand's purpose is crucial before diving into branding. This purpose serves as a strategic compass, guiding all decisions related to providing triple value, developing a sustainable offer, and creating a sustainable brand. It ensures consistency and direction across all actions, both strategic and operational.

Simultaneously, efforts must be made to anchor the sustainable offer in the market. This involves understanding how consumers perceive value and segmenting the market accordingly to identify different behaviours and reactions towards sustainable offers. Targeting specific segments that align with the proposed offer is crucial, as is positioning the brand not solely on sustainability values but also offering additional benefits and reassurance to consumers about the performance of the sustainable offer. This step marks the starting point for developing a strong and consistent brand image around sustainable products.



Above: Business Model Canvas. 2010. Strategyzer. https://www.strategyzer.com/library/the-business-model-canvas

Below: FlourishingBusiness Canvas. 2014. Antony Upward. https://flourishingbusiness.org/download-flourishing-business-canvas/



6: Financial approach – Unveiling the layers of value in entrepreneurship

When it comes to entrepreneurship, value creation is always a central issue. It's commonly understood that this value can take various forms: financial, societal, human, and so on. However, the conventional tools used to characterise a project's business model often focus solely on its financial viability. In simple terms, a project is financially viable if, structurally, total revenues exceed total costs. This vision, especially for Low-Tech projects, needs revision. We need to explore tools that integrate the multiple layers of value in entrepreneurship, challenging us to adopt new approaches.

6.1. A focus on financial viability

Many tools are available to characterise a company's business model. Let's take a look at one of the most widely used: the Business Model Canvas (BMC).

The BMC is a tool developed by Alexander Osterwalder and Yves Pigneur[5] that visualises a business's main components. It defines how a company creates and delivers value. The BMC takes the form of a matrix containing nine blocks: value propositions, customer segments, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.

Graphically, the tool has a central block, "value propositions", to describe the different types of value provided to customer segments through a product or service.

The blocks related to customer value creation and revenue generation are to the right, focusing on understanding customer needs, choosing distribution channels, and managing customer relations. To the left are the blocks describing how the company's activities (with and without partners) and resources should be structured to support the value creation defined in the blocks on the right. This structuring implies costs that need to be measured. The business model of any entrepreneurial project can be analysed from a BMC perspective, and its financial viability is deduced by comparing the revenues generated by the project with the costs associated with the structure of the company running the project.

Low-tech entrepreneurial projects can take many forms, right down to teaching customers to create themselves the value defined in the BMC. This single view of value when questioning the viability of a project is insufficient in a Low-Tech state of mind.

A growing imperative to evolve towards a holistic view of value

The Triple Bottom Line (TBL), introduced by John Elkington in the 1990s, is the idea that a company's (and, therefore, an entrepreneurial project's) performance is not limited to traditional financial indicators. The term "Triple Bottom Line" alludes to the last line of a profit and loss statement.

Three interconnected dimensions must be considered: economic, social, and environmental. Each dimension can be linked to the three Ps: profit, people, and planet.

- Economic dimension (profit): it focuses on classic indicators based on financial value, such as revenues and costs.
- Social dimension (people): it examines the company's impact on society, looking at the social value created or destroyed for all stakeholders (customers, employees, etc.) impacted by the company's decisions.
- Environmental dimension (planet): it examines the environmental value and assesses the ecological consequences of the company's activities.

While this holistic approach stimulates sustainability, it does have its limitations, such as the complexity of arriving at objective and shared measures of value. Nevertheless, it has led to the emergence of tools for assessing corporate business models that consider these three dimensions. Here, we illustrate a recent tool: the Flourishing Business Canvas.

The Flourishing Business Canvas [6] (FBC) is a new-generation collaborative visual tool for designing flourishing, aligned business models.

This design tool provides a common language in a practical visual framework to enable entrepreneurs to collaboratively sketch, prototype, design, improve, understand, share, measure, diagnose, and, most importantly, tell stories about their company's business model. There are similarities with the BMC presented above; the main difference is that FBC considers the context in which the value proposition occurs. The full context of any business on this planet is the environment. Then, society is nested in the environment and depends on a healthy environment. Similarly, society has created the economy to help members meet their needs better. Having established this nested set of contexts, we can now explore how financial value affects social and environmental spheres.

References and Further Reading:

[5.] Osterwalder, A., & Pigneur, Y. (2010). Business model generation. John Wiley & Sons
[6.] Upward, A. (2014). Flourishing Business Model Canvas https://flourishingbusiness.org/

Above: Pete Edgeler. Sussex Trug Making. June 2016. Flickr.
https://www.flickr.com/photos/pete_edgeler/26744479015/

The canvas presents four perspectives : People, Value, Process and Outcomes.

People represent the WHO of the company's business model. Humans/people are why any business or community initiative exists, so this perspective describes who is engaged and the company's relationships with them. It tells us who is influenced and impacted by the enterprise, the key co-creators, their needs, how the business connects with those within the company's ecosystem, and what relationships are required.

Next is the value perspective, also known as the WHAT in a business model. Value is defined as the relative worth, utility, or importance of something. Value is always experienced as a co-creation between two or more parties. There has to be something to value and someone to value it. When these two things come together, value is experienced or co-created.

The third perspective on the Flourishing Business Canvas is Process, also known as the HOW of your business model. This perspective is about how a company will develop and build the products/services that enable value to be co-created, allowing the company to exist.

The fourth and final perspective on the Flourishing Business Canvas is Outcomes, also known as the WHY of a business model. This perspective explores the outcomes or impact an enterprise or community initiative wants to create and generate in the world. Impact is described through the enterprise or community initiative goals, which are based on the purpose or vision of the enterprise.

Understanding the four perspectives (Who, What, How and Why) helps you visualize the core construct of any business model. All four perspectives are required for Low-Tech initiative to exist.

Microcredit and Crowdfunding

Funding through microcredit and crowdfunding provides crucial opportunities to support sustainable entrepreneurship. By providing small loans to entrepreneurs often excluded from the traditional financial system, microcredit helps stimulate the creation of sustainable businesses in disadvantaged communities. These funds can be used to start ecological initiatives such as organic farming, access to clean water, or the development of renewable energy sources.

Similarly, crowdfunding, with its ability to mobilise a large number of people to finance projects through online platforms, offers a pathway to capital for sustainable entrepreneurs. This helps raise funds and creates a committed community around the business and its environmental and social goals. More precisely, we can distinguish between two forms of crowdfunding:

- Crowdlending constitutes a participatory loan in which the project owner must repay the investors according to predefined terms.
- Crowdfunding proper constitutes a participatory donation, with or without a counterpart. These counterparts can vary enormously, ranging from symbolic to material advantage for the donor. In this case, donors can become the product's first customers (and ambassadors).

By combining these innovative funding approaches, sustainable entrepreneurship can benefit from accessible and participatory financial support, thereby promoting the development of innovative and sustainable solutions to current environmental and social challenges.

Above: Matthieu Leroux. Norwegian pot. February 2023. L'avant d'apres
https://lavantdapres.fr/product/marmite-norvegienne/

7: Norwegian Pot Workshop: A Sustainable Business

This section introduces a group educational workshop to reflect on the functionalities of the Norwegian pot and the business that could be created around it. The entire 4-hour workshop is described below.

Introduction to the Workshop and Objectives (5-15 minutes)

Set the scene: "What if we imagined launching a business around the Norwegian pot? One that allows everyone to cook while reducing energy consumption? A way to cook food more sustainably, with reduced environmental impact. An easy-to-use pot that encourages awareness of energy usage from a sustainable perspective".

Method: The workshop's goal is to imagine how to create a business around the Norwegian pot with student teams.
The Norwegian pot[7], Norwegian cooker, Norwegian stove, Insulated cooking pot, Heat retention cooker, Hay box cooker or fireless cooker operates on the principle of heat retention. Here's how it works:

- Initial heating: First, the food is brought to a boil in a pot on a heat source, such as a stove or fire.
- Transfer to the Norwegian cooker: Once the food has reached boiling point, the pot is removed from the heat source. The hot food and pot are then placed inside the Norwegian cooker, which is an insulated container.
- Heat insulation: The Norwegian cooker is designed with efficient thermal insulation, which traps the heat inside. This allows the food to continue cooking gently in its residual heat without requiring an external heat source. The device ideally should be isolated against three modes of heat transfer:
  - Conduction occurs within solids (such as wood or metals) and involves the direct transfer of heat through a material by the propagation of thermal energy from one particle to another. Heat always flows from hotter regions to cooler regions. Poor conductors, also known as insulators, include materials like gases, wood, wool, and polystyrene.
  - Convection is related to the movement of fluids, resulting in the transport of heat. Fluids, such as water or air, are set in motion by the temperature difference and carry heat with them from hotter regions to cooler ones. To reduce convection, it is important to minimise air movement (closed enclosure; bulk insulation such as wool, cellulose...).
  - Radiation: In this mode, a hot body emits electromagnetic radiation (in the infrared wavelength spectrum). Radiation is transmitted without needing a particular medium and thus also occurs in a vacuum. When a system absorbs electromagnetic energy, it converts it into thermal energy (i.e. heat). To block radiation, reflective materials (such as aluminium foils) can be useful.
- Slow-cooking: The food continues to cook slowly inside the Norwegian cooker for several hours, harnessing the trapped heat. This slow-cooking method helps preserve nutrients and flavours while saving energy.

So, the Norwegian cooker is an eco-friendly and energy-efficient cooking method, ideal for dishes that require long, slow cooking, such as stews, soups, and braises.

Energy Impact: The environmental impact is linked to energy reduction. Note: Faced with this observation, it is understood that one of the levers to reduce environmental impact related to energy expenditure can be its utilisation.

Idea: The intention behind conducting this workshop is to collectively address an example of reflection on the business of the Norwegian pot and the "low-technicisation" of food cooking in an interactive way through critical and open discussion.

Discussion about the obstacles and motivations of Low-Tech (20-30 minutes)

Method – Note ideas:
Learners are invited to consider the following fundamental question: What are the advantages, disadvantages, incentives, and obstacles to adopting a Low-Tech approach or product?
Participants are asked to note ideas using 👎(for obstacles) or 👍(for motivation) on a piece of paper, symbolising respectively:

- 👎the obstacle against the relevance in terms of entrepreneurial and sustainable ideas (related to socio-economic issues);
- 👍the motivations and advantages in the broad sense (more autonomy, sustainability, economy, comfortability);

Concerning obstacles, some examples can be given:

- Technical incompetence in manufacturing;
- Technical inability;
- Scientific incompetence;
- Lack of tools, materials, plans;
- New uses;
- Usage discomfort;
- Fear;
- Additional equipment.

Each group chooses ideas to present.

References and Further Reading:

[7.] See: https://wiki.lowtechlab.org/wiki/Marmite_norv%C3%A9gienne/en
[8.] Free Circularity Deck https://www.circularitydeck.com/
[9.] 30 Principles of Resilience Coaching https://environnement.brussels/

Above: L'avant d'apres. Tracer de loin. May 2021. L'avant d'apres https://lavantdapres.fr/lentreprise/

7: Norwegian Pot Workshop

Write the company's purpose and the value proposition (product) (20-30 minutes)

Method: Each group describes its value proposition to meet market needs. Students can emphasise sustainability, technical assistance (e.g., plan), or comfort.

Furthermore, they discuss the product (and the value proposition). They can write one sentence on a paper with both the company's purpose and value proposition.

- The company's purpose encapsulates the broader impact it aims to have on society, the environment, its stakeholders, and its customers.
- The value proposition summarises a business's advantages to consumers who purchase its products or services.
- The product is the tangible or intangible offering a company provides to its customers.

Then, each group presents it.

Idea. What are we going to sell? Plans? Some parts? Tool rental? Workshops to make boxes? Etc.

Choose the company's model (20-30 minutes)

Now that the company's purpose is known, learners can investigate the kind of economic model they will adopt according to the value proposition. Another way to present this step is to ask to what extent their company will fall within a circular economy, collaborative economy, functionality economy, reduction economy, or social and solidarity economy...

Regarding the circular economy, the following card sets can be helpful to give new ideas or to animate the discussion:

- Free Circularity Deck [8]
- 30 Principles of Resilience Coaching[9]

Fill the Flourishing Business Canvas (30-45 minutes)

While filling out the template, learners should focus on the interlocked contexts (environment, society, economy) on the one hand and the specific aspects related to the territory (material resources, human resources, skills, and knowledge) on the other. The ecosystem dimension sometimes involves considering existing businesses, either in the same type of activities or in related activities. In particular, it is interesting to consider businesses whose waste can serve as useful raw materials.

An emphasis is placed on resources, human resources, and nature (territory) (for example, local aspects).

Sustainable Brand (15 minutes)

Idea. Before materializing the offer with a product/service, it is necessary to build a brand to identify this offer. The brand name, slogan, and logo will be defined in this phase. The brand name should satisfy the following seven criteria:

- Evocative: The brand name should clearly communicate what the company or product does.
- Meaningful: The brand name should express an element of positioning.
- Original: The brand name should allow differentiation from others.
- Memorable: The brand name should be memorable, pronounceable, and if possible, simple.
- Attractive: The brand name should appeal to the target audience or sector.
- Transferable: The brand name should be able to work for future products.
- Adaptable: The brand name should be adaptable to other languages or cultures.

We can keep attention to the three dimensions of the triple value model:

1. The needs of the stakeholders
2. The development of a sustainable offer
3. The creation of a sustainable brand

Then, each group presents it.

Pricing (20-30 minutes)

Idea. Each group can consider the best price (the fairest price for the planet) to sell its product. It is important to keep in mind both economic (profitability) and environmental (sustainability) objectives. To set the price, one can also use the price of a new stove or even a fitted kitchen as a reference. One can also take into account the expected energy savings on an annual basis to determine an expected payback period.

Every member of the group can also individually give their minimum acceptable price and maximum acceptable price for the product, then take the average to get an idea of the average price. Try to be innovative in selecting or creating a fair pricing policy. Could this policy reinforce the Low-Tech mindset?

Funding (20-30 minutes)

Idea. Each group must consider financing options such as microcredit or crowdfunding. If learners choose crowdfunding, it is pertinent to inform them how they will trigger this funding: what arguments will they propose to potential stakeholders? What involvement in the overall project? What are the eventual counterparts?

Conclusion (20-30 minutes)

Finally, each group presents the different reflections and enterprise proposal stages. After a Q&A session, an exchange between the various groups can lead to common reflections on the answers to the different questions, thus leading to a new and improved enterprise proposal.

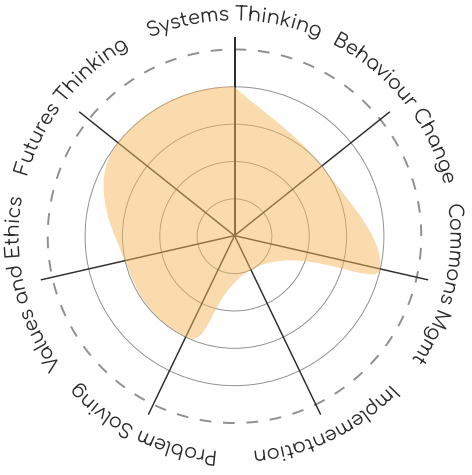
Territoire

Santiago Perez

5 lessons

Above: SlimMars 13. Village in Valley in Mountains. July 2024. Pexels. https://www.pexels.com/photo/village-in-valley-in-mountains-27064734/

Territoire



Learning Hours

To succesfully complete this module the learner will engage in:

Activity	Activity Description	Hours
Lecture	Delivered content and discussions	12
Self-Directed	Research, reading, and project preparation	18

Module Objectives

This module examines the concept of Territoire as a socio-ecological framework, exploring the dynamic relationships between society and its spatial and ecological contexts. Learners will engage with interdisciplinary perspectives to understand how human and environmental systems co-evolve, employing tools such as systems thinking and spatial analysis. The module highlights how the integration of "Territoire" and social-ecological system (SES) approaches can address complex challenges such as resilience, governance, and sustainability.

Learning Outcomes

1. Define and critically analyse the concept of "Territoire" within socio-ecological and spatial contexts.
2. Compare and contrast the "Territoire" and SES frameworks.
3. Explore interdisciplinary approaches to understanding nature-society interactions.
4. Assess resilience within social-ecological systems using principles of systems thinking.
5. Apply spatial and historical analysis methods to study territorial dynamics.
6. Critique the role of power, agency, and sense of place in shaping socio-ecological systems.
7. Develop strategies to address "wicked" problems through integrated approaches.
8. Formulate solutions for sustainable resource management grounded in territorial and SES principles.

Above: Matheus Bertelli. Laughing Woman in a Garden. January 2023. Pexels. https://www.pexels.com/photo/laughing-woman-in-a-garden-15291235/

1: What is a social-ecological system (SES)?

In their activities, people continuously adapt to their situation, with goals that shift in response to changes in their environment (Faysse et al. 2014). Through constant interaction with their environment, they adjust their techniques and practices to moderate the consequences of environmental change on their livelihood. In doing so, they shape the configuration and trajectory of their landscapes, for example, through investments in new irrigation devices or changes in cropping patterns to cope with the occurrence of droughts. However, suitable adaptation actions at one's own scale of reference are not always reachable. In these cases, people must change more radically, with actions, either intentional or unintentional, that push toward a regime shift or a change in what has been defined as the social-ecological system (SES) within which they are embedded.

What is a social-ecological system (SES)?

A SES deals with the relationship between a society and its environment. SESs are linked or coupled human-environmental systems and represent a movement of two mirror images coming together. The first image is that of ecologists and other natural scientists increasingly focusing on the social dimensions of the environment and ramifications of the human world as integrated into and a part of the natural world rather than an external source of disturbances on ecosystems (Berkes and Folke 1998, Folke 2006). The second image is of social scientists noting how the bio-geo-physical context directly affects people, their institutional arrangements, overall culture, and society. SESs move towards a holistic view of the social and ecological system as a single system with effects and feedback from one subsystem to another or as a single complex system (Gallopín et al. 1989, Folke 2006).

In Figure 1 The large box represents an entire social-ecological system, including its components and social and ecological subsystems. The two large arrows in the middle represent interactions between them. For example, the arrow targeting the ecological sub-system represents human influences on nature. These are the outcome of processes influenced and/or driven by citizens, commercial interests, institutions (rules, regulations, customs), and the human-built infrastructure. They impact the ecological sub-system in numerous, often invisible ways mediated through ecosystem processes and functions because of myriad abiotic and biotic interactions. The arrow targeting the social sub-system represents the outcome of all these factors.

In SESs, the system is an integrated whole comprising multiple social agents and biophysical elements with some connectivity and interaction level (Meadows 2008). Ostrom (2007) proposes a characterisation of SESs that includes four important subcomponents: (1) users/actors, (2) governance systems, (3) resource units, and (4) resource settings. This organisation recognises that these subunits interact to produce outcomes embedded in social, economic, and political settings as well as biophysical ones. SESs are often referred to as complex adaptive systems with dynamic interactions at multiple scales (Folke 2006), leading to the generation of outputs in which the aggregate behaviour emerges from the interactions of multiple individual agents and is qualitatively different from the sum of the individual behaviours in that it cannot be inferred from the behaviour of any single individual entity (Miller and Page 2009). SESs are therefore considered to exhibit a degree of self-organisation in which the system organises without central control (Mitchell 2009).

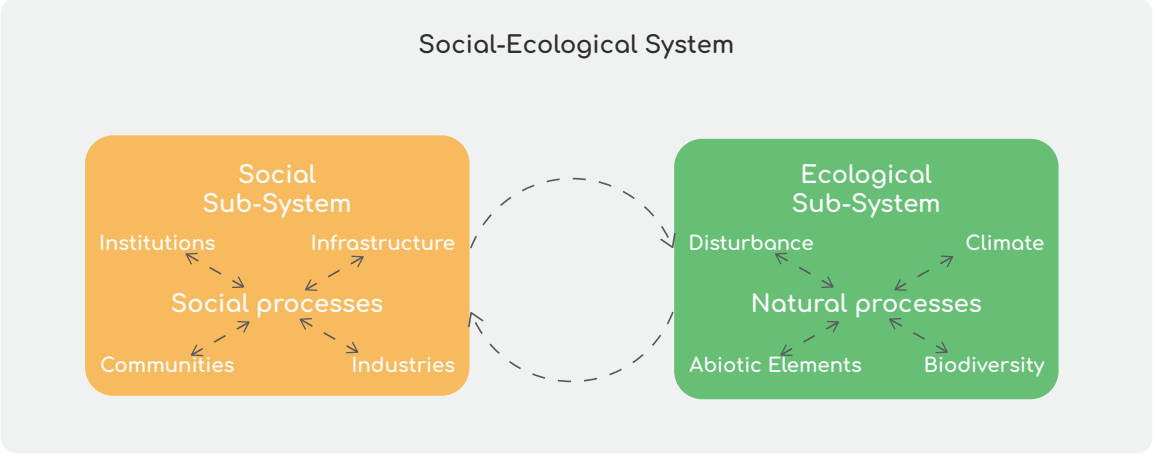


Figure 1: Graphical representation of a social-ecological system. https://doi.org/10.3389/fpubh.2019.00085

Above: Pixabay. White Windmill. May 2017. Pexels. https://www.pexels.com/photo/white-windmill-414807/

1: What is a social-ecological system (SES)?

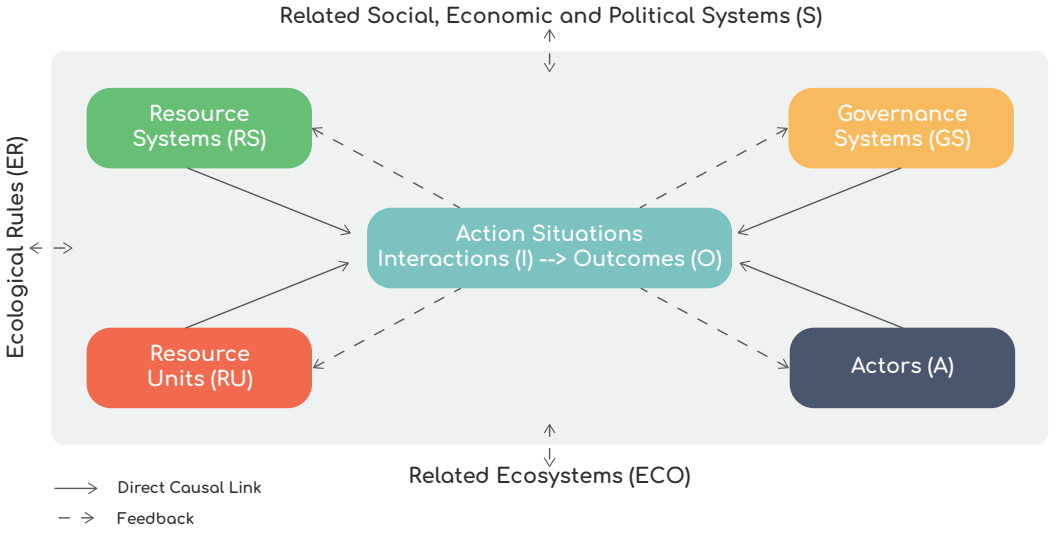


Figure 2: The social-ecological system framework.
Based on Ostrom (2009) and Epstein et al. (2013). http://dx.doi.org/10.5751/ES-07239-200155

The social-ecological system framework consists of four core subsystems (RS, RU, GS, A) organized around a central action situation in which interactions occur and outcomes are produced. Additional subsystems (S, ECO, ER) impact all core subsystems.

Natural scientists were moving toward these coupled complex systems approaches (e.g., Levin 1999) and reaching out to social scientists (Gunderson et al. 1995). Simultaneously, social scientists were also drawing on complexity and systems. Throughout the 1990s, researchers began to combine the biophysical context and societal variables to understand institutional arrangements as they are affected by changes in the system (Ostrom et al. 1994). Berkes and Folke (1998) took the next step, bringing social and natural scientists together to analyse coupled SESs.

SES analysis requires an interdisciplinary effort (teams, approaches, and methods). More recent efforts to integrate this field of study and deepen our understanding include applied robustness frameworks (Anderies et al. 2004) and the continuing development of Ostrom's SES framework (Ostrom 2009, McGinnis and Ostrom 2014). Consequently, the conceptual apparatus of the SES is expanding, including mental models of agents to incorporate knowledge dynamics (Gray et al. 2012) or infrastructures as mediators and affordances in system dynamics (Anderies 2015).

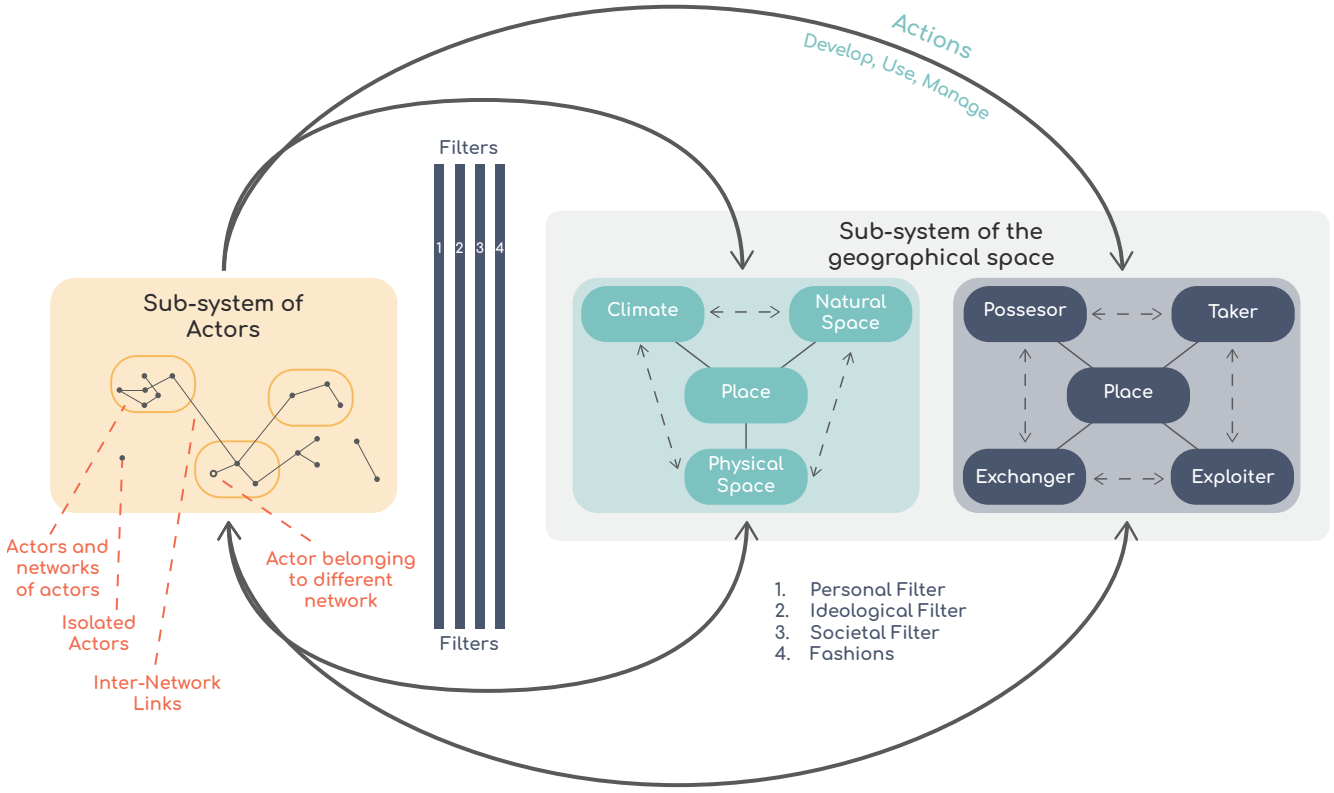
More recently, SESs have been explicitly used to reconcile "wicked" problems of natural resource management and its effects on humanity. For example, how do gradual changes such as accumulation of pollutants, habitat loss, or changes in societal values slowly erode the strength of the dominant feedback in a system until a threshold is reached and a different set of feedback suddenly becomes dominant, leading the system to reorganise rapidly into a new regime? What knowledge and social learning systems are required to navigate these regime shifts? From a practical point of view, SES studies attempt to resolve questions of human and environmental conflict, frequently addressing how groups organise, formally or informally, to manage common-pool resources, paying attention to the contingency of specific landscapes (Walker et al. 2004, Kinzig et al. 2006).

What's next?

In analysing relations between people and their environment, we can assume that people assess the status and state of their environment primarily through self-reflection on their life conditions. We have the capacity to maintain or improve our condition through our relations with others and our immediate physical environment. The core variables of life conditions are relative to each person, but some are shared, and many interact. Therefore, the coordination of adaptation patterns for society is required, which provides a systemic view of our realities.

Parallel to the SES approach, there is another academic tradition providing useful interdisciplinary conceptual frameworks to understand and explore nature-society systems: ecological and institutional analysis building on the concept of social-ecological systems (SESs; Berkes and Folke 1998, Gallopín 2006), and social geography using the francophone originated concept of territoire (Le Berre 1995, Debarbieux 2004). Those traditions have much in common, and we try to demonstrate their potential for mutual benefit. Considering them in parallel, we enhance the understanding of the contributions of these traditions to building more sustainable realities (Carpenter et al. 2001). The main idea behind those traditions is to provide a conceptual toolbox to identify the key interactions that could have a cascading influence on the system(s) we analyse.

Understanding the concept of territoire as a complex system whose characteristics and dynamics are based on the interactions between actors and their spatially explicit ecological context provides an operational approach to understanding social-ecological interactions.



Above: The territory as a complex system: an operational concept for planning and geography.
Based on Le territoire comme un système complexe : un concept opératoire pour l'aménagement et la géographie », L'Espace Géographique 2006-2, pp. 115-132.

2: But, what is a territoire?

The notion of territoire gained popularity among French-speaking social scientists over the last three decades. It is mainly used by French-speaking social geographers but has received some use beyond the francophone community. We avoid translating it into "territory" because that word is commonly used in relation to administrative boundaries, and that is only a small part of what territoire actually implies. We propose to use the concept of territoire within a larger social geography perspective.

Developed initially from spatial appropriation and political control rooted in the making of the nation-state (Weber 1978, Sassen 2008), the concept of territoire was mainly used in ethology from the 1920s to the 1960s, after which it was brought back into the humanities by anthropologists, sociologists, and geographers, who suggested that one can better understand human behaviour by studying how a group takes ownership of a territoire through processes of identity and belonging. Defined in social geography as a spatial mediator of all social life (Di Méo 1999), territoire becomes both a social and a lived space, including political and ideological dimensions of space.

"Territoire is a reordering of space (...) it can be considered as the informed space of the biosphere."
- Raffestin (1986:177)

In the 1980s, francophone academics in human geography constructed and used territoire as an operative concept to understand relationships between societies and their environment (Di Meo 1998). The term gained popularity due to quantitative and spatial approaches dealing with the notion of space in "the absolute mode" (Agnew 2011:322). Disputes among geographers deal with the nature of space itself. Referring to Lefebvre (1974), social geographers understand territoire following the dialectics of space. Territoire is socially produced, conflictual, and a medium for social representations (Séchet and Veschambre 2006). This focus takes a holistic approach to account for the complexity of social phenomena in their spatial dimensions (Rougerie and Beroutchavili 1991). Social geography (i.e., the branch of human geography that focuses on social theories and their spatial components) considers territoire in its economic, ecological, ideological, and political dimensions (Di Méo and Buléon 2005). Complexity hinges on individuals and groups' importance of their connections and relationships with a physical space (Raffestin 1986).

Evolving from its ethological sense, territoire describes how individuals and groups act, think, behave, and deploy and implement strategies inside a given controlled space. In other terms, territoire emerges through the interactions that individuals and groups have with their environment within a specific geographical area (Debarbieux 2007). Thus, it can be seen as a socio-spatial system at different spatial scales (local, regional, national, and global). It is embedded in a physical space and socially produced, including both material and immaterial dimensions (Berque 2000). The material dimension refers to both the physical and ecological nature of space. The immaterial dimension refers to social representations, ideas, images, and imageries produced within a specific space, which transform space into territoire, making it socially and culturally invested (Debarbieux 2003, Ferrier 2003).

In this complex socio-spatial system, society and actors act in a given space while space and its biophysical components act on societies and actors with their social and cultural representations, heritage, and other factors (Vant 1986). Di Méo (1987:561) introduces "the spatial dimension, proposed as an additional criteria in social distinction and classification." As such, there is a bidirectional feedback loop between the social systems and the biophysical system. These complex systems are theorized as socio-spatial combinations (Di Méo and Buléon 2005) composed of infrastructures (landscapes, communication networks, geology) and a superstructure (cultural and social schemes, policy, power).

Increasingly, environmental issues have come to the centre stage of this body of research while recognizing society's dependence on environmental components of the system: the experience and management of environmental risks (Duchêne et al. 2004), the development of biodiversity conservation policies, and the use of environmental symbols in cultures and strategies (Lepart and Marty 2006, Mathevet and Godet 2015). Many social scientists investigate the territorial construction of environmental resources (Bonnefoy et al. 2000, Gumuchian and Pecqueur 2007), whereas other research focuses on environmental risks and their consequences on territoire with a focus on its resilience (Coanus et al. 2010). This conception of territoire leads to environmental planning approaches that put emphasis on natural environmental systems (Selman 2000) and feed discussion on the management of landscape dynamics inherited from both cultural and natural processes.

With territoire growing ever more popular in the 1980s and 1990s, the word has become increasingly polysemous. Criticisms emerged on the imprecise use and inadequacy of the notion of territoire in a globalized context (Badie 1995). Agnew (1994:57) coined the term "territorial trap," referring to the nonsense of an idealised notion of territoire contained within well-defined boundaries. Anglo-Saxon geography has long constrained territoire (i.e., territory) to political geography, regarding it as the spatial basis of power, inspired by Foucault and Lefebvre (Fall 2007), and paying attention to borders, controls, and state regulation (Sack 1986). The meaning reserved for the notion of place is close to territoire. Place is understood as a term mixing location on the Earth's surface, a locus of individual and group identity, and the scale of everyday life (Castree 2014). Places are seen as "glocal": local actions responding to but also influencing wider sets of rules and relationships at different scales (Cresswell 1996). There is a conceptual proximity between place and territoire because both terms carry not only spatial reference but also social and moral references (Tuan 1979). Since the 2000s, territoire has been assessed for its own specificity by Anglo-Saxon geographers. In this trend, Elden (2010) points out that one should consider a territoire in its historical perspective, building on the Foucauldian root of the concept. A number of techniques and laws contribute to drawing the picture of territoire as a political-technological-social construct. Today, the concept continues to evolve. For instance, following Vanier (2008), many social scientists associate networking and mobility analysis with territoire and introduce new concepts such as multiterritorialities, establishing connections between socio-spatial dynamics of territoire (as a local and contiguous geographical area) and reticular logics of networks (Cortes and Pesche 2013).

Above: Kelly Lacy, Kelly . Town by the Water in Cambodia. November 2023. Pexels https://www.pexels.com/photo/town-by-the-water-in-cambodia-19063383/

3: System, Space, and Society: Common roots, with divergences

Both SES and territoire share interdisciplinary concepts to explore nature-society dynamics. Both concepts identify sets of interactions with components of different natures, including social and ecological ones. Both traditions converge toward analysing the coevolution of these components as they are framed by this network of interactions. Hence, both accept the notion of either SES or territoire as complex adaptive systems (Moine 2006), with social components pushing the interactions and physical space orienting them as their privileged medium. To understand the possible evolution of these complex systems, we need to be able to examine key components and interactions. Our purpose in pushing the comparison of both traditions is to enable a more thorough analysis of these nature-society systems and to establish the suitability of mixing elements of both, as well as identifying the potential benefits of such mixing. We first compare both traditions and their handling of interactions between nature and society. Second, we review how each tradition engages in system thinking, how they use the notion of space, and their approach in addressing societal change and decision- making.

Nature-society interactions

Both SES and territoire are used to represent the interactions between ecological and social spheres as a knowable unit of study for the evolution of land and resource planning and management. They build on various trends dealing with this intersection for the sake of natural resources management, including sustainable development (WCED 1987), with acknowledgement of social, ecological, and economic components as joint drivers of development. SES features categories of users or systems of resources that enable accounting for these strong interactions. In contrast, territoire builds on representations based on landscapes, including the articulation of resources, and social and political schemes as SES components.

SES and territoire differ in their way of understanding humans and the relative weight given to nature and society in these interactions. Where territoire tradition considers actors as individuals that act on their environment (Di Méo and Buléon 2005) or inhabitants as individuals that think and build spaces (Hoyaux 2002), SES tradition often considers users and stakeholders (Ostrom 2007) with a strategic relation to their environment. Although both epistemologies handle relationships between nature and society, SES tradition starts with ecology or a scoping of the natural resource base, considered as an operating space for society, and brings in a continuous extension toward institutional analysis (Cote and Nightingale 2012). In contrast, territoire tradition starts with social perspectives and, taking a nondeterministic approach to geography, considers that humans can modify nature and move away from its constraints (Ferrier 1984). These nature-society interactions, understood as territoire, could only be defined through the relationship humans develop with space and time (Di Méo and Buléon 2005). Hence territoire tradition uses a constructivist approach, with nature emerging through perceptions and interactions with society, whereas nature has its own existence in SES tradition. Consequently, SES tradition can more easily incorporate knowledge coming from physical and biological sciences.

System approach

Both traditions build on the concept of system, as introduced by von Bertalanffy (1968). They adopt the same three-dimensional description and analysis of a system: functional, structural, and dynamic (Checkland 1981). They also share the view that a system, particularly its structure, should be studied through three lenses: physical, including components, phenomena, facts, and elements; logical, looking at the relationships between components that determine the functioning and evolution of the system; and holistic, defining the identity of the system. Both traditions consider that system identity emerges from the interactions between the components and gives meaning to these interactions (Wilson 1990, Deffontaines et al. 2000, Holling 2001).

Analyses of SES and territoire adopt a similar stance concerning scales and levels of organisation: time, space, and social groups (Mathevet et al. 2003, Cote and Nightingale 2012). The system's evolution depends not only on present conditions but also on past disturbances. Long-term social-ecological research highlights the pathways, regimes, and transitions of both SES and territoire. For instance, Singh et al. (2013) provide understanding of the SES characteristics that frame the management of resources and its evolution in time. Barles (2009) proposes an adaptation of long-term social-ecological methods to the localised scale of territoire. The time dynamic is examined in territoire tradition through the production of the narratives that explain the sequence of nature-society relations producing the territoire. In the SES tradition, the temporal dynamics are acknowledged through studying interactions between slow and fast variables and understanding path dependencies and dynamic models of the system. Cross-scale interdependences from determinants set by large spatial entities or social groups and organisations are also demonstrated through both traditions (Gunderson and Holling 2002, Lévy 2003).

While sharing several points of view on system analysis, SES and territoire traditions diverge in their view of systems in the relative weights given to various dimensions of system descriptions. SES focuses more on functions, whereas territoire focuses more on structure. Consequently, analysis of these systems initially involves flows and feedback related to functions for SES, whereas connections of layers make up the whole of territoire. Whereas the territoire tradition defines interactions, relationships, and representations between humans and their environment, the SES tradition conceptualises the origin and regulation of flows and feedback (Walker et al. 2006) with an increasing focus on the agency behind these (Ostrom et al. 1994). Lastly, the SES tradition describes a hierarchy of systems and system components within a nested system (Gunderson and Holling 2002, Ostrom 2007). In contrast, territoire tradition explains the representations and uses actors have of a biophysical and spatial organisation of a specific area and the contribution of these multiple representations to social phenomena such as a sense of place (Clark and Stein 2003). Consequently, dynamics in a territoire-based analysis come from individual and political choices, whereas an ecosystem perspective frames matter more in SES tradition.

Above: Juan Felipe Ramírez. People Walking in Alley in Bogota. December 2023. Pexels. https://www.pexels.com/photo/people-walking-in-alley-in-bogota-19676359/

3: System, Space, and Society: Common roots, with divergences

Space

Territoire is naturally embedded in space, which provides the objective biogeochemical substrate within which human actors interact to represent and construct a territoire. The functions of SES depend on the location of natural biophysical elements and their stocks and flows in the function of human activities and interventions.

Defining space, however, highlights the challenges of boundaries, i.e., the spatial limits of the system. In both epistemologies, the clarity of boundaries has faded because of the relativism of definitions, being in both cases acknowledged as depending on analyst and stakeholder viewpoints. Integration of individual perspectives makes it challenging to delineate boundaries that make sense for all components of the system.

The importance given to space differs between the traditions. Territoire tradition aims at building representations of spatial realities via discourses, photography, and cartography (Di Méo and Buléon 2005), working as stories of space (de Certeau 1990). Enhancing geographical knowledge proceeds by adopting and transforming these representations of space (Debarbieux 2004). In SES, results are not necessarily spatially projected (Cumming et al. 2006), and system components can be determined or described without specified geographic boundaries or spatial references. However, spatial mismatches between social and ecological systems concern SES scientists (Carpenter et al. 2001, Walker et al. 2004). Space is but one possible dimension of interactions between nature and society.

Relation to society

Both SES and territoire consider society as essential to their existence and the dynamics of change. They integrate an analysis of agency triggering changes or sequences of decision and negotiation, producing narratives of evolution. They also aim to bring the knowledge produced by research into policy arenas to generate science-policy interactions. This relation to society is ambiguous in many cases because several practitioners of both traditions have the simultaneous goal of describing society as a part of the system and its dynamics but also being part of the change itself, guiding collective action, be it for more sustainability, economic efficiency, or social justice.

SES and territoire face this tension around decision-making, issues of power, and consideration of humans in diverging ways. SES analysis primarily focuses on understanding system functions. When decision-making is considered, including feedback toward system governance, the SES tradition appears to be more subject to an action research stance, with a focus on learning and adaptive capacity (Fazey et al. 2007; Fabricius and Cundill 2010, Béné et al. 2011). In contrast, social geographers take a more critical stance, including stepping back and raising potential issues of inequities held by conceptual choices (Foster and Clark 2008, Hornborg 2009, Cote and Nightingale 2012). Although this reflexivity is not specific to any of these traditions, we observe a difference in its practice. This affects how power issues are considered: social geographers are more concerned about the consequences of their work on power balance and social justice, whereas SES analysts focus more on power relations as controls on flows or feedback among components. This divergence in dealing with this tension regarding intervention is the root of one of the main dimensions of debate among both traditions.

Synthesis of comparison

Territoire has a strong foundation in social components, i.e., the behaviour of social groups and organisations or individuals, households, or families. These agents are conscious of their environment and their place within that environment. The effectiveness of their control on the territoire they feel they are part of depends on the coordination of multiple agent actions and reflects the capacity to formulate an intention and implement a collective action. This issue of collective action is also well-developed within the SES conceptual framework (Ostrom 2005). However, hereafter, we discuss two concepts that are more developed in the territoire tradition and are central to understanding processes of collective action. The first one is "sense of place," which contributes to defining identity and reflects the agent's consciousness of the environment and of his or her place within it. The second one is power, which contributes to defining governance and agents' abilities to coordinate to control the system.

Sense of place refers to the meanings of and attachment to a setting held by an individual or group (Tuan 1977) and can include an individual and group identity related to a place. Sense of place is related to a set of concepts that have long been part of studies in cultural geography under different forms, particularly through phenomenology (e.g., Tuan 1977), but also in social psychology and related fields (Lewicka 2011). As such, it has been included in social geography and hence in the territoire conceptual framework, where it has been used to develop a critical approach to conservation or development projects. Human geographers now consider the sense of place a keystone in their conceptual framework (Massey 1993, Agnew 1994). Much of the early SES work operated in the vicinity of sense of place research. Initially focusing on Indigenous societies' historical intimacy with land, this trend of SES analysis showed that these groups build their cultural identity as well as adaptive institutions and knowledge through experiences in their ecosystems (e.g., Berkes and Folke 1998, Berkes et al. 2003, Tengö and Belfrage 2004). This perspective has been used to question the greater disconnection between human and natural systems, for example, because of urbanization and changes in agriculture (Leopold 1966, Jackson 1994, Folke et al. 2011). More recently, interest in sense of place has been renewed in SES literature for its potential to motivate and foster stewardship of ecosystems and places (e.g., Andersson et al. 2007, Barthel et al. 2010, Tidball and Stedman 2013, Chapin and Knapp 2015). In this system view a sense of place is both an outcome of an actor's experience with a place and an attitude that influences the behaviour of actors and mediates feedback between people and their environment (Cumming et al. 2015). Additionally, the influence of sense of place has been used to investigate how actors adapt to changes such as industry closure or climate change (Fresque-Baxter and Armitage 2012, Marshall et al. 2012). For example, a strong attachment to a place can positively influence social-ecological resilience in the face of small incremental changes through adaptive capacity. Still, it may hinder transformational change (Marshall et al. 2012). Sense of place has also been shown to serve as a powerful driver for individual and collective action to repair or enhance the traits of a place, e.g., after a disaster has occurred, resulting in virtuous cycles of ecosystem stewardship (Tidball and Stedman 2013, Stedman and Ingalls 2014). The use of sense of place as a construct in SES is still in its infancy, and the SES conceptual framework could be further enhanced by integrating some features of the relatively more nuanced understanding of place, as recently developed and mobilized in social and cultural geography studies, to characterize better the relation between users and systems of resources (Mathevet et al. 2016).

Above: Carlo Verso. aerial photography of field during day time. September 2017. Unsplash. https://unsplash.com/photos/aerial-photography-of-field-during-day-time-flpUxVFfkl0

4: Bridgeing the two traditions

Beyond similarities and differences, bridging requires a thorough verification of the consistency of one concept against the conceptual framework with which we try to incorporate it. We first consider some of the concepts originating from SES followed by those from territoire.

Flows, feedback, and evolution

Several analyses of SESs describe and measure flows of materials and energy occurring within a given space (Chertow et al. 2013). These flows are analysed because of interactions within the SES. SES approaches to studying flows can enhance territorial knowledge. For example, Barles (2009) computes the material balance for Paris, France, pointing at the link between urban metabolism and activity density, highlighting interactions between territorial planning and economic development. This analysis complements those based on territoire. This addition of flows within territoire analysis entails completing the portfolio of interactions considered in trade-offs and negotiations. Economics has pointed out the existence of externalities due to material flows that are not managed (e.g., nonpoint source pollution due to heavy use of pesticides and fertilisers in agriculture). Current governance systems are challenged in accounting for these externalities because they lack valuation systems and institutions to handle them (Sarker et al. 2008, Martin and Stahn 2013). An extensive flow analysis, including the agency involved in these flows, should better inform these governance processes.

Beyond material and energy flows, SES analyses study dynamic interactions through feedback loops acting directly or indirectly across the SES and involving changes in behaviour, decision, and adaptation (Cumming et al. 2006, Folke 2006). Interacting agents use perceived feedback in their decision processes. Feedback loops manifest within and across multiple temporal and spatial scales in nested SESs and act as helpful lenses for understanding change in complex human-nature systems (Liu et al. 2007). SES experience in considering various temporal and spatial scales within a unified but modular framework is potentially useful for territorial analysis. Feedback loops are essential to understand the complexity of territoires and to avoid the territorial trap raised by Agnew (1994): reciprocal feedback at a larger spatial scale interacts with the local spatial scale in the long term. For example, the production of nutrients in agriculture may improve farmer livelihoods in one region. Still, it may drive the eutrophication of downstream fisheries or be considered a source of greenhouse gas emissions with severe consequences for communities most vulnerable to climate change elsewhere. At the interface between SES and territoire, territorial ecology emerges as a new field, extending industrial ecology to a more extensive set of entities. Territorial ecology proposes to analyse social-ecological interactions within a territoire. It analyses and accounts for social-ecological flows with multiple lenses: biogeochemical processes, land use and land cover, and socioeconomic interactions (Buclet 2015).

Information flows are central to feedback loops. Primary information is obtained from ecosystems collected through measurements designed by scientists, experts, and public authorities. It then enters the social process of understanding and the public debate, underpinning decision-making by economic agents, public organisations, or associations. These decisions feed back to the ecosystem, affecting harvest or pollution rates. This loop permits engaging with system complexity while providing an operational setting for observing system outcomes and movement toward preferred SES goals (Plummer 2009), possibly with stakeholders as monitoring agents (Stringer et al. 2006). SES studies consider other information flows acting solely within the social subsystem that may indirectly affect ecosystems. These flows include social learning and the strategic revelation of private information (Laffont and Martimort 2002). SES approaches to information can be articulated within a knowledge network and a shared territorial vision (Junqua and Moine 2007, Ormaux 2007). Analysis of system evolution and its underlying mechanisms is central to SES tradition and influences its thinking regarding agent adaptation. Modelling the resulting dynamics and interactions across system elements heralds from a tradition of evolutionary analysis in biology and population studies in which agent behaviour responds to stimuli from current events according to rules influenced by past experience. Evolutionary approaches have been adapted to institutional analysis from formalised dynamic analysis underpinning some of the SES literature. For instance, institutional change is understood as an evolutionary phenomenon related to social institutions and norms, including evolving social learning capacity (North 2005). There is scope for further fertilising ideas and methods from this tradition into a more dynamic territorial analysis.

Above: Anton Malanin. people walking in forest trail. October 2018. Pexels. https://unsplash.com/photos/people-walking-in-forest-trail-DqDqHYFPvC0

4: Bridgeing the two traditions

Sense of place and power

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The notion of power is also intrinsic to the territoire conceptual framework. Indeed, derived from ethology, the idea that a territoire results in the actual and symbolic domination of a portion of space implies the exercise of power. Power explains the ability of a group to appropriate and control a specific portion of space. It is then necessary to study power relationships and potential conflicts among all the agents acting within a territoire. By combining historical and geographical context in the analysis of a given territoire evolution, this tradition integrates the Foucauldian perspective of genealogy, power, and governmentality. It may adopt a political ecology lens (Robbins 2012). SES research has been criticised for insufficient treatment of agency and power imbalances as it has been used with a resilience perspective (Cote and Nightingale 2012). However, the SES, as defined by Ostrom et al. (1994) addresses explicitly power relationships in terms of resource units (either single or multiple) and the claims by multiple groups on a single resource unit or the effects of one stakeholder group on another as mediated either directly or indirectly through resource units. There have also been some innovative responses to this criticism in terms of addressing and theorising agency in transformative changes (Westley et al. 2013), and several SES researchers have explicitly addressed power imbalances and the capacity of individuals and groups to influence social-ecological changes (Peterson 2000, Crona and Bodin 2010).

DEBATES: POTENTIAL FOR ENHANCED UNDERSTANDING OF THE NATURE-SOCIETY RELATION?

The SES and territoire concepts are powerful in their capacity to explain nature-society relations. Both share several features: the differences highlighted here and in the literature have more to do with academic historical traditions rather than fundamental conceptual differences. We next explore how the two traditions function regarding three core issues of the nature-society interface: resilience, norms, and evolution.

Above: Quang Nguyen Vinh. Small sprouts growing on burnt ground. January 2021. Pexels. https://www.pexels.com/photo/small-sprouts-growing-on-burnt-ground-6415962/

4: Bridgeing the two traditions

Relevance of these traditions to address specific or general resilience

A precise definition of nature-society systems is needed to provide suitable context for resilience assessments. Here, we consider how each concept performs when used for resilience assessment. General resilience is related to the essence of the system: What is essential in a system to consider that it is still the same system despite its transformations? The structural emphasis of the territoire tradition tends toward a more conservative view considering system components, particularly the social components: people are part of the system, and their social relations are assumed to be the essence of the territoire concept. This view hinders much potential evolution if resilience is an aim. With its more functional emphasis, the SES approach requires the identification of essential system functions, e.g., food security, and assumes that actors and social structures will adapt and change to preserve functions. These adaptations and changes may be violent for some groups of people. The capacity of the SES tradition to assess these possible negative consequences is then at stake. Conceptual tools related to identifying and clarifying power relations or sense of place may help, as well as historical perspectives on sequences of prior transformations. The specific set of values behind the choice of essential functions should be addressed explicitly, as well as the question of who is defining these values.

The specific resilience of a system to a given source of perturbation (Anderies et al. 2006) does not match the territoire approach, which necessarily includes the whole system level with all its connections. The territoire tradition is associated with endorsing viewpoints of people within the system at stake. These people cope with all perturbations and cannot elaborate on a specific source of perturbation abstractly or in isolation. Changes in flows and possible feedback induced by the system's evolution can be explored through their effects on system functions. The resilience of a state, e.g., clear water state of a lake, as in Carpenter et al. (2001), can be assessed through the SES approach, with the possibility for the system to flip into another system, e.g., the eutrophic state. A territoire approach will start with the system's current state and assess the threats to its remaining state under expected perturbations. In this case, "resilience of what" is essentially the resilience of a current situation analysed through the filter of the multiple perspectives and interests within the population.

Joining the two traditions is promising because it enables (1) clarity in identifying important system components to enable system dynamics and change and (2) identification of system components that could be weakened through this change. Building on the differences between the traditions, considering their regard for and handling of societal issues, including power relationships and decision-making, can also enrich the analysis and definition of essential functions to be maintained. These, in turn, promote greater awareness of the social implications of a decision being considered, negotiated, or taken.

Consequently, the concepts emphasise the notion of transitions and their integration across time and space. This emphasis brings the notion of change in the domain of existence itself into the planning process. Beyond panarchy's view of transitions between regimes (Gunderson and Holling 2002), these transitions can be considered as shifting from one dominant domain of resilience to another or changing the proxy used to account for general resilience. The transitions between dominant proxies are eventually the place of power issues, with all the underlying norms, as far as these shifts can be influenced.

Normative issues

In SES, the values that sustain any particular function, including the social structures and conventions that conservation actions rely on for norms, are more or less explicit. The SES tradition starts with a more positivist stance, seeking to specify predefined categories to describe and explain the system's dynamics under scrutiny. In this case, creating an objective description is possible because the SES scholar typically sits outside of the system in question. The aim is then to explain the SES trajectory and to provide indicators of its performance and resilience. It is always possible, however, that outcomes of these analyses are used by stakeholders or policymakers out of the scope or domain of the assessment process, thus misconstruing the intended outcomes. This has been criticised as a risk of "instrumentalisation" (Voß and Bornemann 2011). SES scholars have become aware of this and seek to be more reflexive on this potential bias (Tàbara and Chabay 2013). With an action-research stance, SES analysts bring in implicit norms when involved in the decision process. Power relations appear more in explaining the system's dynamics and emerged as one dimension in a grammar suitable to describe the evolution of the SES (Bousquet et al. 2015). SES analysts are hence internalised in the system, and their intervention is analysed as such with power lenses. A normative input of the SES approach is to recognise that the multiplicity of relationships and feedback loops makes the SES particularly complex, adaptive, and unpredictable.

Territoire is used more critically, in the same line as political ecology (Batterbury et al. 1997). This includes the analysis of decision processes according to their consequences in terms of power balance and the evaluation of public policies, with explicit positions of groups of stakeholders (Chaponnière et al. 2012). This emerging trend in evaluation, accepting pluralism, is still in its infancy, developing within the territoire tradition. The space where human activities occur is transformed by culture, reflecting a feeling of belonging to a place or a network. Sense of place is the central defining feature of the territoire. The geographical space becomes a milieu or a nature as soon as people become aware of their environment, build representations, and act upon them. Artificialised, endowed of meaning, possessed, and assimilated, this nature becomes a territoire (Le Berre 1995), enabling and legitimising the emergence of regulation of its use (Caron 2015). This perspective on nature-society interactions is more loaded with subjectivity, contrary to a more functionalist perspective on nature-society interactions that assumes a factual existence of nature, independent of society. This characterises the tension between those who argue that the environment should be seen principally as a social construct and those who believe that our environment is a factual reality independent of our constructions or representations (Goldman et al. 2011, Robbins 2012). The same debate is played out at the global scale in relation to sustainable development and the definition of "safe and just" operating spaces for humanity (Leach et al. 2013).

Above: James Wheeler. Building With Tree. October 2010. Pexels. https://www.pexels.com/photo/building-with-tree-1534057/

4: Bridgeing the two traditions

Historical viewpoint

Relation to the past and using historical knowledge to explain nature-society relations in their time dependency is a further dimension of debate between both traditions. For social geographers, it is helpful to anchor further analysis of social-ecological relationships in historical and social dimensions to understand better how power and social structures drive the trajectory of the territoire (Reclus 1876–1894, Robbins 2012). They take a constructivist stance based on the assumption that the very definition of the components of the system the researcher is studying is a social construct that results from the evolution of social representations and uses of physical space. On this basis, some authors criticise using reference states for system analysis, particularly for its ecological components (Crumley 1994, Bestelmeyer 2015). They argue that it is an arbitrary choice and crystalises a normative stance of the researcher, resulting from a social representation of nature and influenced by power relations and ethical position (Mathevet et al. 2015).

By contrast, reference states are typically used by SES analysts to answer the "Resilience of what?" question. From their understanding, SES analysts develop a more future-oriented stance, elaborating knowledge on drivers of change and generating capacity to handle them to anticipate potential system thresholds. Rather than referring to some idealized notion of the past, they remain open to multiple future objectives of the system state. This is sometimes formalized as "viability constraints," entailing exploration of whether they are reachable given initial states, known dynamics, and possible interventions (Aubin 1991, Deffuant and Gilbert 2011). Historical knowledge is still used to build this knowledge on drivers of change by analysing past trajectories and their explanations based on sets of key variables with independent rates of change. These variables are characterised as fast or slow, the latter of which are growing concerns for environmental policies that may lock in unfair situations because of institutional rigidities explained by slow variables (Brock and Carpenter 2007).

Above: Kevin Malik. Woman Sitting on a Wall in Park and Writing in a Notebook. August 2021. Unsplash. https://www.pexels.com/photo/woman-sitting-on-a-wall-in-park-and-writing-in-a-notebook-9032644/

5: Conclusion

SES and territoire have now converged, dealing essentially with the same objects and providing suitable ways to specify and discuss what is at stake with an evolution meaningful for some groups of people. This convergence has been enabled via opportunities such as the whole process around the Resilience 2014 conference and the conference itself (http://www. resilience2014. org/), as well as bridging scholars who started to import and tailor concepts from one tradition to the other or developed methods of analysis embedded in communities. However, the differences in their epistemologies and their weighting of social and natural components in driving nature-society evolution can lead to different perspectives. These differences are problematic when using the concepts primarily for policy-oriented objectives of sustainable management of the nature-society interface. This is problematic because it can lead to inappropriate or unfair policies if some key variables are missed and not brought to light in reflective processes (e.g., adaptive management, monitoring, evaluation, etc.). We have pointed out several possible bridges to strengthen the association of both traditions to improve resilience assessment and management.

SES and territoire have various ways of dealing with system dynamics, space, and society. For example, SES scholars are now working on the specificity of spatial analysis (Cumming et al. 2015). Territoire increasingly engages the analysis of flows and possible feedback, importing from ecology the metaphor of metabolism. Emerging fields of "circular economy" and "territorial ecology" (Allais et al. 2015) are consistent with this perspective (although still with a specific view on production rather than resilience), and the inclusion of actor-network theory in social geography (Koch 2005) goes in this direction as well. Therefore, territoire is increasingly seen as a matrix for multiple autonomous entities of diverse natures in interaction, including humans, each of them involved in the dynamics of the whole, and hence very close to the perception and evolution of SES.

The common aim of managing the resilience of territoire or SESs requires reflexivity. Social geographers have developed an experience of this that could fit the current needs of several SES scholars, enhancing their capacity to handle controlled interventions in policy processes related to system function and resilience. Explanation of the framing induced by dominant worldviews through narratives could reinforce social network analysis for power relation identification in the recent evolution of the SES toolbox. Including the nature-society analyst within these networks or sets of worldviews is a crucial step towards reflexivity, on which both traditions are working.

The temporal dimension, central to the issue of change, can be holistically and fully addressed through the union of both traditions, with analysis more rooted in social history to understand the slow variables involved and methods turned toward scenario analysis and future more detached from existing components (Peterson et al. 2003). Hence, the union of SES and territoire traditions facilitates a deeper collective thinking of the broader community toward its own development, and we expect this chapter will be part of that job.

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How to Run a Low-Tech Hackathon

Above: John Walsh. LT4Sustain Hackathon Conclusion. June 2024. Châlons-en-Champagne.

1: The Low-Tech Hackathon: Main Objectives

The goal of a Low-Tech Hackathon is to co-create Low-Tech solutions, both technical and non-technical, in order to address current issues within a specific local area.

This event brings together students from diverse disciplines, institutions, and experience levels for an intensive and collaborative process. Each team is guided by two coaches: a teacher and a local actor, to help them achieve their objectives effectively. The expected outcomes of a Low-Tech Hackathon are:

For Students:

- Apply their knowledge to real case studies, with roles distributed based on the diversity of their expertise.
- Discuss varied approaches informed by their cultural and academic backgrounds.
- Co-design solutions in collaboration with the local population
- Engage with professionals and stakeholders.
- Develop a clearer vision of potential career paths post-graduation

For Teachers and Trainers:

- Gather feedback on the implementation of Low-Tech methodologies.
- Exchange best practices and observe students' learning behaviours.
- Propose sustainable solutions tailored to local populations' needs

For Socio-Economic Actors:

- Gain a better understanding of the relevance and functionality of the Low-Tech approach.
- Network with teachers, trainers, and students.
- Interact with students potentially seeking internships or employment opportunities.

Above: Paul Hendrick. LT4Sustain Pitch Event. June 2024. Châlons-en-Champagne.

2: Organisational Methodology

Organising a Low-Tech Hackathon begins with clearly defining its objectives, which serve as the foundation for creating a robust methodology. The following four key stages provide a framework for planning and implementing your event:

Prior Training in Low-Tech Educational Modules

Before the event, it is highly recommended that participants undergo training in Low-Tech principles and processes. This training equips them with the foundational knowledge needed to design effective, innovative, and context-specific solutions during the Hackathon. Educators can develop training sessions tailored to their curriculum or adopt existing Low-Tech learning resources.

Pre-Hackathon

This phase focuses on organisational, logistical, and resource management tasks essential for a successful event:

- Identify the needs and opportunities within the chosen local area
- Establish collaboration links with socio-economic and community actors.
- Prepare documentation for evaluation, communication plans, and inclusivity strategies.
- Confirm participation of students, mentors, coaches, and external stakeholders.

During the Hackathon

The Hackathon itself consists of intensive, collaborative activities designed to produce tangible outcomes. The event agenda should include:

- Team ideation sessions to develop Low-Tech solutions.
- Facilitated workshops and prototyping activities.
- Opportunities for participants to engage with local actors.
- Interim feedback sessions to keep teams on track.

Organisers are responsible for ensuring that all activities run smoothly, with a focus on collaboration, creativity, and community engagement.

Post-Hackathon

Once the event concludes, the focus shifts to evaluating outcomes and capitalising on results. Post-event activities include:

- Assessing participants' learning outcomes and the solutions developed.
- Collecting feedback to improve future events.
- Documenting key data, including lessons learned, participant experiences, and measurable impacts.
- Maintaining relationships with local actors and fostering an ongoing collaborative community.

Each of these stages encompasses activities grouped into four categories:

+ **Logistics and Management:** Resource allocation, task management, scheduling, and workspace preparation.
+ **Low-Tech Design Approach:** Facilitating creativity, prototyping, and solution development.
+ **Dissemination:** Communication and inclusivity efforts throughout the process.
+ **Evaluation and Assessment:** Structured assessment of solutions, as well as participant and stakeholder feedback.

Low-Tech Design Approach

The Hackathon structure should integrate principles of Low-Tech design with collaborative methodologies like Design Thinking. The process includes:

1. Understanding local needs and identifying problems.
2. Ideating solutions that are accessible, resource-efficient, and sustainable.
3. Prototyping solutions using available local resources.
4. Testing and refining the designs through feedback and iteration

This design approach ensures that solutions are grounded in the realities of the chosen context while fostering innovation and critical thinking among participants.

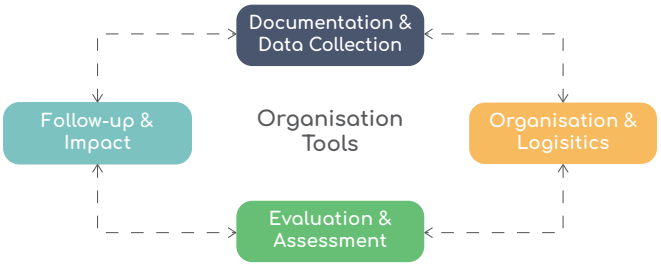
Above: Ceri Almrott. LT4Sustain Hackathon. June 2024. Châlons-en-Champagne.

Organisational Tools

The success of a Hackathon depends on effective organisational tools that simplify and optimise planning, communication, and collaboration. The following categories of tools are recommended:

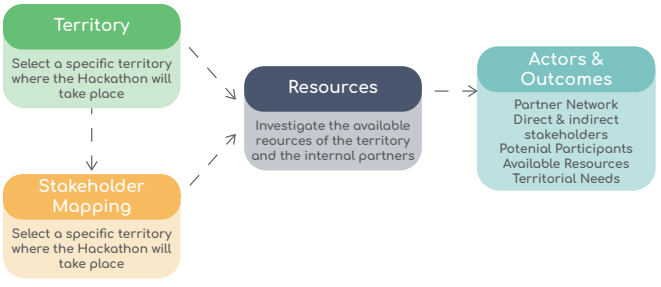
- Open Source Tools: Free and accessible options that align with the Low-Tech philosophy.
- Collaborative Platforms: Tools that promote teamwork and knowledge sharing.
- Data Collection Tools: Platforms for feedback, assessment, and documentation.
- Sustainability-Oriented Tools: Resources designed to facilitate environmentally responsible event management.

When selecting tools, prioritise simplicity, inclusivity, and sustainability to align with the Low-Tech ethos.



Territorial Context and Resources

The Low-Tech approach emphasises using local and territorial resources to develop solutions influenced by geographical, historical, and cultural factors. These resources are mobilised within a framework of internal territorial development, requiring attention to local specifics and projects. Identifying these resources early is crucial for the smooth running of a Low-Tech hackathon, as it provides valuable information on needs, participants, potential partners, and available resources (tangible, intangible, human). The hackathon activities should prioritise local resources, and careful consideration should be given to the factors outlined in the figure below.



Logistics and Organisation

The Low-Tech approach promotes the philosophy of reducing and efficiently using resources. The event aims to generate a positive social impact while minimising all directly generated environmental impacts. In this context, a Low-Tech hackathon must be built on a philosophy of socio-ecological responsibility.

Planning Responsible Events

From a Low-Tech perspective, a responsible event can be defined as one that integrates the principles of this approach, along with behaviours and measures focused on ecological and social responsibility. ADEME (the French ecological transition agency) particularly recommends ensuring:

- An easily accessible and responsibly managed venue
- Eco-designed stands and equipment
- Proper management of dismantling
- More sustainable catering options
- Promotion, evaluation, and communication aligned with the approach

Participants

For a hackathon to be successfully carried out, the profiles and roles of the participants are essential elements. It is recommended that participants engage with the Low-Tech modules. However, it is important to consider the different categories of participants and their specific roles in a hackathon:

+ **Students**: Those who have completed low-tech training
+ **External speakers:** Local citizens
+ **Jury:** Evaluators of the proposed solutions
+ **Speakers:** Presenters on low-tech-related topics
+ **Coaches and mentors:** Advisors and supervisors for students
+ **Organising team:** Responsible for the event's logistics
+ **Support staff:** Operators, technicians, and others

Legal permissions

Legal permits are essential to ensure compliance with the agreements of all participants and the relevant authorities. Obtaining these permits is context-specific and must be done carefully to secure the necessary authorisations. We recommend consulting permits for public spaces, local infrastructure, multimedia recording and/or broadcasting, and confidentiality agreements.

Above: Ceri Almrott. LT4Sustain Hackathon. June 2024. Châlons-en-Champagne.

Transportation
Although each event depends on the objective of its organisers and the infrastructure available to carry out the necessary travel, strategies must be taken into account to reduce the environmental impact of transport.

Catering
It is important to emphasise that the local aspect of the events and the Low-Tech approach should prioritise a short food chain. This means involving local professionals and associations to ensure a balanced and varied menu for all diets with low emissions and using local and seasonal products (preferably organic). It is recommended to use only reusable and, when appropriate, recyclable utensils.

Accommodation
Strategies can vary from traditional bookings with hotel professionals to sharing infrastructure with local stakeholders involved in the event. It is important to ensure safety, accessibility, and a minimum level of comfort. It is advisable to obtain legal permits from local authorities to use open spaces if necessary.

Key Locations during the event
A hackathon can be held in various locations. To ensure a smooth experience, organisers should provide access to the following spaces: a main workspace for meetings, a makerspace for workshops, dissemination areas, catering facilities, and accommodation.

Contingency plans
Like any event, organising and implementing a hackathon may encounter unforeseen situations. Creating a contingency plan is crucial to address these challenges and preserve the initial objectives and plans. We recommend conducting a risk analysis of the essential elements for the success of a hackathon: participants, infrastructure, transportation, food, and health and safety.

Special Guests and Partners
A more significant impact can be achieved by complementing the event with opportunities for exchange, debate, and dissemination on topics related to Low-Tech practices. Organisers can include conferences featuring speakers, researchers, and recognised experts from various fields to broaden perspectives on the Low-Tech approach and address topics relevant to the territoire

Inclusivity strategy
The Low-Tech approach can play a key role in addressing issues related to social inclusion. The activities carried out during the hackathon create spaces that foster inclusion and the development of solutions tailored to the local problems identified. Since the Low-Tech approach is based on integrating local realities, it is essential to ensure broad and diverse inclusion of all social groups.

Documentation and data collection
The objective is to collect all the key evidence and data needed for a post-event assessment of the quality of the content developed, with the aim of improving it. Furthermore, this collection of information will make it possible to identify areas for improvement for future editions and create new projects based on the Low-Tech approach. More broadly, it aims to collect information to analyse the comments made by participants: students, coaches, juries, external participants, etc

Dissemination strategies of the hackathon
Dissemination activities should follow a series of strategies and recommendations to reach the largest possible audience. The communication plan should outline the target groups, activities, and channels. It is important to note that communication involves three key stages

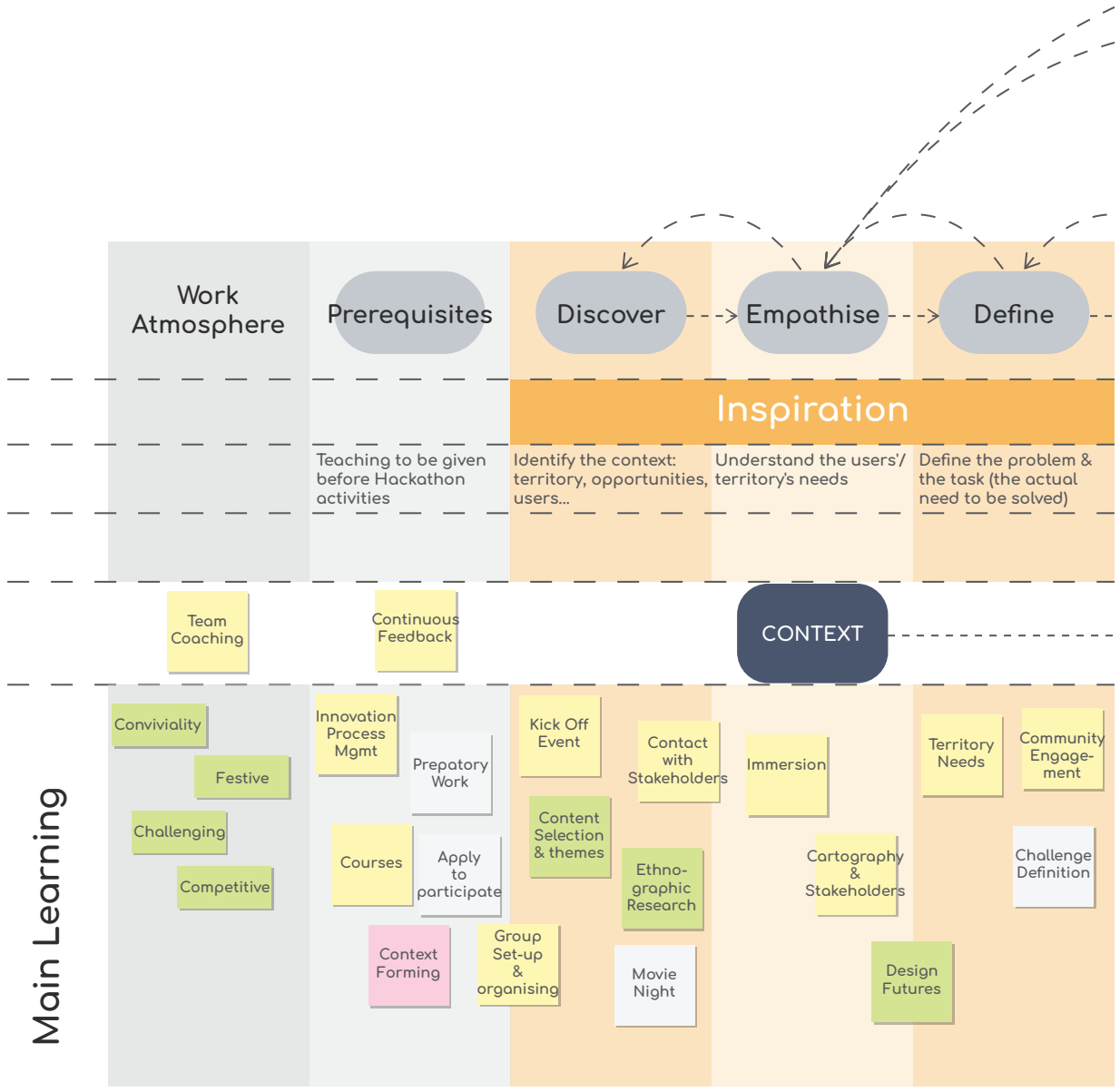
To run a Low-Tech hackathon, begin by preparing participants with foundational teaching (found in this guide) and fostering a convivial yet competitive work atmosphere. Establish teams around shared challenges, engaging relevant stakeholders from the outset.

Step 1: Context and Challenge Formation

Immerse participants in the context by exploring the territory, identifying opportunities, and understanding user needs. Employ methods such as ethnographic research, cartography, and stakeholder engagement to define challenges collaboratively.

Step 2: Ideation and Prototyping

Facilitate ideation workshops to generate innovative Low-Tech solutions. Encourage participants to develop concepts iteratively through model-making and prototyping, utilising simple tools and materials. Offer topical advice and guidance throughout.



3: Running the Low-Tech Hackathon

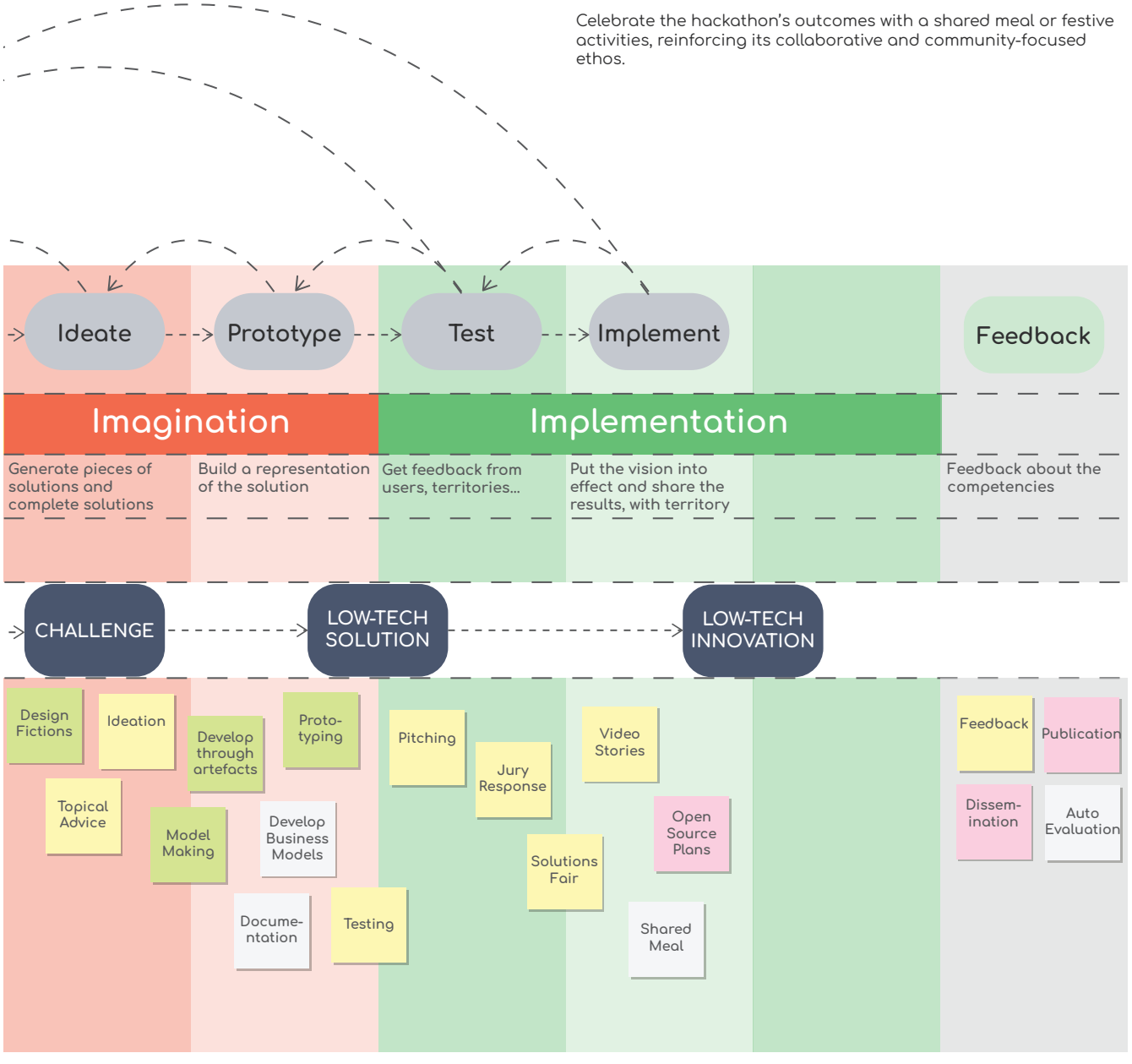
Step 3: Testing and Feedback

Incorporate user feedback regularly to refine solutions. Testing should emphasise functionality, usability, and alignment with the contextual needs.

Step 4: Pitching and Dissemination

Conclude the event with a public showcase, where teams pitch their solutions to a jury and present them at a solutions fair. Document outcomes with video stories and open-source plans for broader dissemination.

Celebrate the hackathon's outcomes with a shared meal or festive activities, reinforcing its collaborative and community-focused ethos.




LOW TECH + SUSTAINABILITY
lts
LEARNING IN LOW-TECH TO PROMOTE SUSTAINABILITY

“Low-Tech is a way of thinking and designing that focuses on creating simple, practical, and accessible solutions. These solutions are not just theoretical, but are designed to meet local needs, using fewer resources, promoting sustainability, and encouraging more inclusive approaches. At its core, it challenges conventional methods and inspires new ways of doing things appropriate for their context.”

What's next?

This book is an invitation to action - a guide for teaching, learning, and applying Low-Tech principles to build a sustainable, resilient, and equitable future. Here's how you can engage:

For Educators

1. **Incorporate Low-Tech into Your Curriculum**
   Design courses or modules that explore Low-Tech principles, focusing on simplicity, repairability, and sufficiency. Use the case studies, frameworks, and exercises in this book as tools to inspire critical thinking and practical innovation.
2. **Facilitate Hands-On Learning**
   Create opportunities for students to experiment with Low-Tech solutions in real-world contexts. Encourage prototyping, collaborative projects, and community engagement to deepen understanding.
3. **Promote Systems Thinking**
   Help your students see the interconnectedness of design, sustainability, and human well-being. Use exercises from this book to challenge them to think holistically and address complex challenges.
4. **Be an Advocate for Change in Education**
   Share the principles of Low-Tech design with your institution, fostering a culture of sustainability and resilience. Collaborate with other educators to integrate these ideas across disciplines.

For Students

1. **Explore the Possibilities of Low-Tech Design**
   Use this book to challenge the assumption that "newer" or "more advanced" is always better. Experiment with designs that prioritise human needs, repairability, and environmental sustainability.
2. **Engage with Community Challenges**
   Apply your knowledge to local issues. Collaborate with peers and community members to develop practical solutions that reflect the values of Low-Tech design.
3. **Think Beyond Products**
   Embrace systems thinking by considering how your designs interact with larger ecosystems, communities, and cultures. Use the frameworks in this book to address the complexity of real-world problems.
4. **Shape the Future**
   Your generation has the power to redefine how technology serves society. Let this book inspire you to be a change-maker in design, engineering, and beyond.

For the General Public

1. **Adopt Low-Tech Solutions in Daily Life**
   Repair instead of replacing, choose durable products, and embrace simplicity in your everyday decisions. Small, intentional choices can make a significant impact.
2. **Support Low-Tech Initiatives**
   Get involved with community projects that promote repair, upcycling, and local sustainability. Look for repair cafés, makerspaces, and similar initiatives in your area.
3. **Advocate for Sustainable Practices**
   Use your voice to support policies and businesses that prioritise sustainability, repairability, and ethical design. Share what you've learned with others to spread awareness.

Together, we can redefine the role of technology in society by focusing on solutions that respect ecological limits, empower communities, and foster a deeper connection between people and the planet. Let this book serve as a catalyst for transformative change in education, design, and daily life.

Reading List

Sustainability and Planetary Health

Raworth, K. Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist. London: Random House Business, 2017.
+ Discussed in Design for Sustainability (pp. 35–37).

Steffen, W., et al. "Planetary Boundaries: Guiding Human Development on a Changing Planet." Science, vol. 347, no. 6223, 2015.
+ Explored in Introduction to Sustainability (pp. 29–37).

Rockström, J., et al. "A Safe Operating Space for Humanity." Nature, vol. 461, no. 7263, 2009.
+ Referenced in Introduction to Sustainability (pp. 31–35).

Meadows, D. H., et al. Limits to Growth: The 30-Year Update. White River Junction: Chelsea Green Publishing, 2004.
+ Examined in Planetary Boundaries (pp. 37–39).

Low-Tech, Simplicity, and Circular Design

Bihouix, P. The Age of Low Tech: Towards a Technologically Sustainable Civilization. Bristol: Bristol University Press, 2020.
+ Cited in The Art of Simplicity (pp. 55–65).

Stahel, W. R. The Circular Economy: A User's Guide. London: Routledge, 2019.
+ Discussed in Low-Tech Entrepreneurship (pp. 215–227).

Manzini, E. Design, When Everybody Designs: An Introduction to Design for Social Innovation. Cambridge, MA: MIT Press, 2015.
+ Referenced in Open Design (pp. 89–97).

Resilience and Adaptability

Folke, C., et al. "Resilience Thinking: Integrating Resilience, Adaptability, and Transformability." Ecology and Society, vol. 15, no. 4, 2010.
+ Explored in Social-Ecological Resilience (pp. 247–257).

Ostrom, E. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press, 1990.
+ Cited in Territoire (pp. 255–267).

Walker, B., et al. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Washington, DC: Island Press, 2006.
+ Discussed in Territoire (pp. 259–267).

Ethics and Responsibility

Jonas, H. The Imperative of Responsibility: In Search of an Ethics for the Technological Age. Chicago: University of Chicago Press, 1984.
+ Explored in The Imperative of Responsibility (pp. 169–201).

Rawls, J. A Theory of Justice. Oxford: Oxford University Press, 1971.
+ Referenced in Ethics and Responsibility (pp. 179–183).

Papanek, V. Design for the Real World: Human Ecology and Social Change. London: Thames and Hudson, 1971.
+ Discussed in Design for Sustainability (pp. 43–47).

Open Source and Participatory Design

Arduino. "Open Source Microcontroller Platform." Accessed at: arduino.cc
+ Discussed in Open Design (pp. 89–93).

von Hippel, E. Democratising Innovation. Cambridge, MA: MIT Press, 2005.
+ Cited in Open Design (pp. 93–97).

Open Source Ecology. "Collaborative Development of Sustainable Tools." Accessed at: opensourceecology.org
+ Explored in Open Design (pp. 91–97).

Traditional and Cultural Approaches

Illich, I. Tools for Conviviality. New York: Harper & Row, 1973.
+ Referenced in The Art of Simplicity (pp. 65–75).

Reclus, É. "L'Homme et la Terre." Paris: Librairie Universelle, 1905.
+ o Cited in Territoire (pp. 259–267).

Schumacher, E. F. Small is Beautiful: Economics as if People Mattered. London: Blond & Briggs, 1973.
+ Discussed throughout the book, particularly in Introduction to Low-Tech (pp. 29–37).

Resources

This section provides a collection of valuable resources to deepen your understanding of Low-Tech principles and enhance your learning experience. These materials include project websites, reports, webinars, and tools developed as part of the LT4Sustain initiative.

Project Website

LT4Sustain.eu

Explore the LT4Sustain project, its objectives, and its deliverables. The website includes updates on project activities and access to key resources.

Deliverable Reports

PR1 - End-Users Requirements Analysis (10.5281/zenodo.14622190)

Developed by ENSE3, this report analyses the needs of educators and learners to guide the development of Low-Tech teaching resources.

PR2 - Replicable Pedagogical Methodology for Low-Tech Education (10.5281/zenodo.14623522)

A comprehensive framework for integrating Low-Tech education into higher education syllabuses.

PR3 - Tailored Higher Education Pedagogical Material on Low-Tech (10.5281/zenodo.14622354)

Customised teaching materials and strategies for effectively introducing Low-Tech concepts in universities.

PR4 - First Implementation in Partner Universities & Feedback (10.5281/zenodo.14623787)

Insights and feedback from the initial implementation of Low-Tech education strategies across partner institutions.

Workshops & Teaching Resources

Low-Tech Ideation Workshop (10.5281/zenodo.14604781)

A practical tool to facilitate creativity and problem-solving during Low-Tech hackathons.

Low-Tech Hackathon Card Deck (10.5281/zenodo.14621654)

A hands-on collaborative tool that explores Low-Tech solutions to complex challenges. Low-

Low-Tech Teaching Resources (10.5281/zenodo.14621500)

A curated collection of materials designed to assist educators in teaching Low-Tech principles effectively.

Visual Pocket Knowledge: Key Principles of the Low-Tech mindset (10.5281/zenodo.14622454)

A creative and accessible publication featuring stories, illustrations, and tips on Low-Tech practices and applications. Perfect for introducing the principles of Low-Tech to a wider audience in an engaging format.

How to Use These Resources

Educators can integrate the syllabuses, hackathon tools, and pedagogical reports into their courses to inspire students. Students can use these materials to deepen their understanding of Low-Tech principles and apply them to projects. General Learners can explore the reports, card deck, and other tools to build their knowledge and engage with the Low-Tech movement.

Glossary of Terms

Adaptive Capacity

The ability of a system, community, or individual to adjust to environmental changes, moderate potential damage, and take advantage of opportunities.

References:

+ Bridgeing the two traditions (p. 247-255)
+ System, Space, and Society: Common roots, with divergences (p. 251-255),

Anthropocene

A proposed geological epoch that marks significant human impact on Earth's systems, including biodiversity loss and climate change.

References:

+ Introduction to Sustainability (p. 43)

Appropriate Technology

Technology designed for specific contexts, emphasising simplicity, affordability, and local adaptability. It contrasts with high-tech solutions by addressing practical needs.

References:

+ The Educational Model (p. 19)
+ Low-Tech as a D4S Approach (p. 51)
+ What do we mean by low-tech? (p. 69)

Circular Economy

An economic model that replaces "take-make-dispose" with "reuse-repair-recycle," aiming to create closed loops of material use and reduce waste.

References:

+ The Educational Model (p. 19)
+ Low-Tech examples of D4S (p. 59).
+ The paradox of Low-Tech entrepreneurship (p. 215)
+ Emerging economic models (p. 219)

Degrowth

An economic paradigm advocating for reduced consumption and production to achieve sustainability and equitable resource distribution.

References:

+ Low-Tech examples of D4S (p. 57)
+ Methods for implementing the low-tech approach (p. 61-63)
+ Low-tech and similar spirits (p. 203)
+ Degrowth as a Global Driver (p.217)

Doughnut Economics

A visual framework that balances human needs with ecological limits. It guides progress by ensuring every person's basic needs are met without overusing Earth's resources.

References:

+ Limits of our planet (p. 47)

Emotionally Durable Design

An approach to designing products that form long-lasting emotional connections with users, promoting sustainability through reduced consumption and waste.

References:

+ Emotionally Durable Design (pp. 139–141)

Inclusivity

A design approach ensuring accessibility and usability for all individuals, addressing barriers such as economic inequality and energy poverty.

References:

+ What is our view of the Low-Tech approach? (p. 9)
+ Inclusivity and Low-Tech (p. 29-37)

Low-Tech

A design philosophy focusing on accessible, resource-efficient technologies that are simple, sustainable, and adaptable to local contexts.

References:

+ What is our view of the Low-Tech approach? (p. 9-15)
+ Why these topics? (p. 24.25)
+ The Low-Tech philosophy (p.51-53)
+ What do we mean by low-tech? (p. 69)
+ Can high tech ever be low-tech? (p. 83)
+ Low-tech and similar spirits (p.203)

Multiple-Criteria Decision Analysis (MCDA)

A framework for evaluating multiple competing criteria, supporting balanced decision-making in sustainability and design contexts.

References:

+ Design as a complex activity (p. 165)
+ Multiple-Criteria Decision-Aiding(MCDA) methods (p. 167-171)

Planetary Boundaries

Nine ecological thresholds regulating Earth's stability and resilience. These boundaries include climate change, biodiversity integrity, and freshwater use, among others.

References:

+ What are Planetary boundaries? (p. 47)

Repairability Frameworks

Guidelines for creating products that are easy to repair, enhancing their lifecycle and sustainability.

References:

+ What makes for a repairable design? (p. 127)
+ Circular Economy (p. 219)

Resilience

The capacity of systems, communities, or individuals to adapt to and recover from challenges or disruptions while maintaining functionality.

References:

+ Introduction to the Three R's (p. 113)
+ What makes for a resilient design? (p. 133)

Right to Repair

The concept advocating for the legal right to access tools, parts, and knowledge to repair one's own products, promoting sustainability and consumer empowerment.

References:

+ Designing to empower autonomy and longevity (p.127)

Simplicity in Design

A principle that prioritises clarity and functionality, focusing on essential features while minimising complexity and resource use.

References:

- Finding beauty in simplicity (p. 73)
- Simple Design (p. 121)
- Craft and Material (p.139)
- Low-Tech and similar spirits (p. 205)

Sobriété

A French concept emphasising moderation and sufficiency, promoting the use of fewer resources to meet needs while fostering simplicity and sustainability.

References:

- Principles of low-tech (p. 71)

Social-Ecological Systems (SES)

Integrated systems of humans and nature, focusing on sustainable interactions and co-evolution.

References:

- What is a social-ecological system (SES) (p. 243-245)

Stewardship

The responsible management of resources, emphasising long-term sustainability, ethical accountability, and community engagement.

References:

- Roots of Environmental Issues (p. 43)
- Synthesis of comparison (p. 251)

Sufficiency

A principle advocating for meeting needs without excess, encouraging balanced resource use within ecological limits.

References:

- Sufficiency definition (pp. 153).

Systems Thinking

A holistic approach that examines the interactions between components within a system, helping designers address complex challenges.

References:

- How to understand the system to develop a resilient approach (p. 133-135)
- Introduction to a systemic approach (p. 155)

Territoire

A French concept that integrates spatial, social, and ecological dimensions to define the character and identity of a place. Unlike "territory," it reflects dynamic interactions between human and environmental systems, emphasising cultural and ecological specificity.

References:

- But, what is a territoire? (p. 247)

Trade-Offs in Design

The balancing of competing design objectives, such as sustainability versus cost, or functionality versus accessibility.

References:

- Introduction to Causal Thinking (p. 157)

Cross-Chapter Thematic Index

Case Studies and Examples

- Low-Tech in Practice
  - Introduction to Sustainability:
    - + Low-Tech Examples of D4S (p. 55-57)
  - The Art of Simplicity:
    - + Case Studies (p. 87-91)
  - The Three R's:
    - + Introduction to the Three R's (p. 113-115)
- Product and System Innovation
  - Framework Laptop and Clockwork Radio:
    - + Art of Simplicity (p. 87)

Tools and Frameworks

- Practical Tools for Low-Tech Design
  - Introduction to Sustainability:
    - + Methods for Implementing Low-Tech (p. 61)
  - FAIR Documentation Principles:
    - + Open Design Basics (p. 97)
- Evaluation and Assessment
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    - + Art of Simplicity (p. 83)
  - Commons Governance Models:
    - + Community Governance (p. 103)

Historical and Cultural Perspectives

- Origins of Low-Tech Thinking
  - Techno-Critical Authors:
    - + Low-Tech as a D4S Approach (p. 51)
    - + Low-Tech and Similar Spirits (p. 202)
  - Historical Role of the Commons:
    - + Community Governance (p. 103)
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    - + Democratic Design & DIY (p. 79)
    - + Emotionally Durable Design (p. 139)
  - Minimalism and Low-Tech Aesthetics:
    - + Finding Beauty in Simplicity (p. 73)

Material Intelligence and Circularity

- Material Selection and Innovation
  - Criteria for Durable and Sustainable Materials:
    - + The Three R's (p. 117)
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    - + Effectiveness, efficiency, and sufficiency (p.151)
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  - Ethical Analysis:
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  - System, Space, and Society:
    - + Territoire (p. 249)

Aesthetic and Philosophical Dimensions

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  - Simple Design:
    - + Designing Reliable Low-Tech (p. 121)
  - Simplicity:
    - + Low-Tech and Similar Spirits (p. 205)
- Ethics of Beauty and Functionality
  - Finding beauty in simplicity:
    - + The Art of Simplicity (p.73)
  - Attention to Detail:
    - + Emotionally Durable Design (p.139)

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    - + Open Design (p. 97)
  - Can high tech ever be low-tech?:
    - + High-Tech Low-Tech (p. 83)
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- Barriers and Threats
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    - + Be an ethical actor (p. 195)

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low tech + sustainability

LEARNING IN LOW-TECH TO PROMOTE SUSTAINABILITY

LT4SUSTAIN, an Erasmus+ funded transnational project, is at the forefront of responding to the increasing awareness of environmental and climate challenges. This awareness, particularly among youth, has led to a demand for social justice. With the coordinated work among six institutions, ranging from higher education institutions to private companies and associations, LT4SUSTAIN aims to raise awareness of Low-tech across society.

LT4SUSTAIN is pioneering a unique approach to technology design. By developing "hackathons" and other "hands-on" events, we are engaging students and industry in a way that improves inclusiveness. Our objective is to equip individuals with the skills to embark on entrepreneurial ventures that focus on sustainable and valuable solutions using a Low-tech paradigm.

Low-tech, based on the principles of usefulness, sustainability and accessibility, empowers practitioners to implement simple (as needed) technologies that are accessible and easily repairable, using common and locally available means. These solutions lean toward inexpensive technological solutions for fundamental and unsatisfied needs while positively contributing to generating a sustainable environment. This concept favours human know-how and practicality, making it an empowering solution for today's and tomorrow's social, cultural, ecological and economic challenges.

This guide presents a series of lessons and frameworks designed to teach Low-tech principles, offering step-by-step instructions for fostering practical and creative skills. From hands-on workshop activities to insights into sustainable design thinking, it equips educators and practitioners with tools to empower individuals and communities. Whether you're crafting new materials, prototyping resilient solutions, or rethinking design for an era of degrowth, this book provides the knowledge and inspiration to drive meaningful change.

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