low tech + sustainability

LEARNING IN LOW-TECH TO PROMOTE SUSTAINABILITY

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DELIVERABLE REPORT

WP1 – D1.1 - User requirements of teachers and students

Version 1.0

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Introduction

In today's world, we have an extraordinary task to face. We have started experiencing the impacts of climate change, and this is only going to get worse. The exploitation of mineral resources is increasing every day to fuel our increasing consumption and there are issues around social justice everywhere. In response to these challenges, scholars have proposed several developmental frameworks to address some of these needs. There has been a development approaches like circular economy, smart city, and frugal city. One of the most interesting of these is the "low-tech" development philosophy.

"Low-tech" as popularised in France through the work of Philip Bihouix among others can be termed as a technocritical approach to meeting core needs in the society in ways that are useful, accessible, and sustainable (Bihouix, 2014; "Low-tech Lab – Les Low-tech," 2022). The "low-tech" approach is seen as practical method to tackle the issues of climate change, resource depletion, and social injustice because of its focus not only on technical aspects, but on more social ones like questioning the needs. Following from the work of ADEME[1], low-tech should meet 5 criteria (BONJEAN Anne-Charlotte et al., 2022):

- *Useful* – Meet the **core** need of the **user** or group of users, and contribute to the sober use of resources i.e., using resources in moderation
- *Accessible* – Based on financial, knowledge, and other resources that can easily be deployed by **users** of the product or system for the entire use-life of the system from creation, to use, repair, and eventual disposal or recycling
- *Sustainable* – Reduce the negative impact on the environment in terms of emissions, material and energy use, and overall adherence to the earth's physical boundaries. This is also highlighted by product systems with extended life which reduce need for replacement
- *Local* – Be adapted to the context of local communities that they are looking to serve and take into consideration other factors of importance to them asides from simply meeting the need
- *Autonomous* – Contribute to the ability of the community to address their own needs and only explore the resources in cases of actual local deficits

[1] ADEME (Agence de l'environnement et de la maîtrise de l'énergie) is the French government agency in charge of public policy in domain of the ecological transition.

Numerous applications for low-tech have been conceived by ADEME as well as many other stakeholders such as LowTech Lab amongst others. In their report "For Low-Tech And Solidarity Metropolises"[2], the ESS laboratory[3] explores the application of low-tech to parts of citizen life (Philippe BIHOUIX et al., 2022). These included housing, transport, well-being, and work. However, this work, as most other publications on "lowtech", focuses mostly on society's needs from an individual's perspective. As such applications that are mostly used for commercial or complex corporate goods and services are rarely discussed. To drive the adoption of low-tech as a widely accepted development philosophy for the 21st century, it is necessary that we show that not only is "low-tech" desirable and applicable to individual needs but that it also adds value when used in the development or more complex corporate systems.

This work looks to add to that said work by investigating low-tech applications first to teaching students about sustainability and then to developing course material for a relevant technical area. First, it considered the application of low-tech to teaching students about sustainability in a hands-on way through a hackathon. This section formed the majority work of the internship. The goal of this section was to understand the necessary competences that students from a wide background of studies (engineering, design, and business) need to develop to be able to apply the low-tech approach to their future careers. This relied on literature reviews, interviews, surveys, as well as collaborative work with other stakeholders under the auspices of the European project – Lowtech for Sustainability (LT4Sustian).

This work is relevant because:

- It clearly identifies the competences that students need to develop to be able to incorporate "low-tech" into their future careers
- It confirms the relevance of these competences from a large group of students and teachers
- It proposes a way that "low-tech" can be incorporated into the teaching of technical/industrial use case

This work is structured into four sections:

- Section 1 shows a description of low-tech from literature

[2] Translated from french – "Pour Des Métropoles Low-Tech Et Solidaires"

[3] ESS lab - Labo de l'Economie Sociale et Solidaire"

- Section 2 details the low-tech needs for students in engineering, business, and design schools through a comprehensive competence framework
- Section 3 includes the processes that were taken to validate the competence framework by surveys and discussions with practitioners
- Section 4 synthesizes the insights of this report

1 Problem description

1.1 Definition of low-tech

The concept of low-tech can be said to appeared at the turn of the 1960s. In the 1970s, as technological innovation began to permeate the economic, industrial and artistic fields, an alternative way of thinking was developed, notably through the work of the philosopher Ivan Illich and his tools for conviviality (Illich, 1973), and Ernst Friedrich Schumacher and his concept of unsophisticated intermediate technologies (Schumacher, 1979). The work of EF Schumacher has inspired a plethora of technology understanding frameworks including low-tech, frugal tech, appropriate technology, amongst others.

In more recent times, Philippe Bihouix proposed seven commandments for charting a course counter to the technological headrush in his book, The Age of Lowtech[4] (Bihouix, 2014). He lays them out as: 1. questioning needs, 2. designing and producing in a truly sustainable way, 3. directing knowledge towards saving resources, 4. seeking a balance between performance and conviviality, 5. relocating without losing the right effects of scale, 6. de-mechanising services, and 7. knowing how to remain modest. In a similar vein, ADEME defined low-tech systems as systems which are useful, accessible (comprehension and financially), sustainable, local, and that favour autonomy (BONJEAN Anne-Charlotte et al., 2022). Arthur Keller also defined lowtechs as systems that show strong sustainability, contribute to collective resilience, and lead to cultural transformation ("Low-tech," 2022). We settled on the definition of one of the LT4Sustain partners, Lowtech-Lab, which defines low-tech as a objects, systems, techniques, services, knowledge, practices, lifestyles and ways of thinking ,that integrate technology in three grand principles: utility, sustainability, and accessibility ("Low-tech Lab – Les Low-tech," 2022). We settled on this as it all the themes discussed by most of the thinkers in this space hinged on these three principles. We created the infographic in figure 1 below to aid the explanation of the fundamental low-tech concept.

[4] Original title in French – "L'age des lowtech"

Figure 1: Low-tech definition infographic

2 Low-tech needs for students

To define the user requirements for teachers of students, we decided to use as much of the resources that were available. Although low-tech is relatively well-known concept in French sustainability circles, it is not as popular in English literature. To obtain a comprehensive view of the requirements of teachers and students for low-tech, we decided to use multiple methods leveraging work done previously and consisting of a somewhat generalisable overview of the requirements of a wide range of stakeholders from different disciplines.

To ensure that we had a good view of the problem, we conducted several key informant interviews with teachers and students from the different target disciplines (engineering, design, and business). In addition to the interviews, we also developed a survey in English and French which was sent through networks in the partner universities.

2.1 Consideration of relevant study areas

One of the challenges that presented itself was the dearth of scholastic literature in the domain of "low-tech". This can be attributed to the fact that "low-tech", the concept of techno-discernment, is an offshoot of the intermediate technology movement primarily based in France. And in this regard, it was different from the more classical definition of low-tech used in English to mean not involving the most modern technologies or methods (Oxford Advanced Learner's Dictionary, 2022). Therefore, the French "low-tech" concept might be indeed present in literature but with different names.

Many similarities can be drawn between the concept of "low-tech" as popularised by Philip Bihouix and others in France (Bihouix, 2014) and the appropriate technology movement proposed for developing countries in the 1970's as an alternative to technology transfer of capital-intensive technology from abroad (Akubue, 2000). However, while appropriate technology focused on innovation that are useful, accessible, and sustainable in the context of developing countries, low-tech is more focused on applications in developed countries. Therefore, to define a competence framework for low-tech, frameworks of many related concepts were reviewed. we considered competence frameworks in sustainability, human-centred design, social innovation, appropriate technology, and open innovation.

The first and most critical competence framework to our work was that of the EU joint research centre (Bianchi et al., 2020) on sustainability education because it considered many of the pre-published competence frameworks for sustainability. The authors considered over 10 well cited

competence frameworks. However, this alone was insufficient as it left out portions of low-tech that touched on increased accessibility of technologies, and human-centred-ness of the design process.

To address these, we incorporated the insights on social innovation education from the work of Peter Russo and Susan Mueller (Osburg and Schmidpeter, 2013, sec. Social Innovation Education). In their work they laid out the necessary knowledge and skills for social innovation which we cross-referenced against the base list from the EU joint centre paper (Bianchi et al., 2020) to identify potential additions. We also reviewed the work of Norman on human-centred design (Norman, 2019, 2013). The biggest new insights from these were being "people-centred" and "using rapid iterations of prototyping and testing". Finally, to ensure that we had everything covered as regards accessibility, we reviewed a competence framework on open innovation (Podmetina et al., 2018). These ensured that we had a well-rounded competence framework.

We also reviewed the competence frameworks of The Shift Project (The Shift Project and Groupe INSA, 2022), Quelhas (Quelhas et al., 2019), and Castro-Sitiriche et al. (Castro-Sitiriche et al., 2012) to ensure completeness of our framework with others in the same space. The Shift Project report was relevant, but it was noted that it only looked to address the education of a part of the target audience for the LT4Sustain project, engineering students, as such although it was a very comprehensive piece, it did not meet all our requirements. On the other hand, the work presented by Quelhas was found to be more generalizable. There were only minor differences between the work of Quelhas et al and the EU JRC. Competence frameworks from all the reviewed literature can be found in tables 1 and 2.

2.2 Merging the different competence frameworks

Having gathered different relevant competence frameworks, it was then important to merge these frameworks into one. One of the immediate challenges was that all the frameworks were not at the same level. The EU Joint Research Centre, Shift Project, and Quelhas frameworks were all at competence level. However, the social innovation and open innovation frameworks were skills and knowledge level. So, to have a unified framework there was a need to aggregate some of the unique skills and knowledge pieces in the two later frameworks into a coherent competence area. Table 3 shows the first competences and frameworks that serve as references while table 4 shows the preliminary descriptions of these competences.

In order to double check that we had not missed anything in the definition of lowtech, we cross-referenced it with the scope of design intervention proposed by Ceschin (Ceschin and Gaziulusoy,

2016) and found that our definition covered all the relevant design frameworks. Ceschin's design for sustainability framework can be found in the appendices. However, for clarity of the survey, we decided to merge competence areas that could be considered together for the purpose of low-tech. The final description of competences used for the survey can be found in Figure 2. These were the changes made to the competences:

- Merging of "Futures Thinking" and "Strategic Thinking": These were merged as students can be thought to need one to be able to carry out the other
- Merger of "Inter-personal management" and "Integrated problem solving": These were merged as these could be considered together as solving problems collectively with people that were very different from the actors.
- Adjustment of "Project management": Project management was adjusted to iterative implementation to specify that the regular project management was not well suited to the low-tech approach. This is because the low-tech development approach was linked to an iteration design process that involved members of the community (users) in almost all phases of development
- Removal of "Self-efficacy" and "Topical knowledge": Self-efficacy was removed because although it would be useful to help people practice low-tech, it could be obtained in many other curricular and extra-curricular activities. Topical knowledge was left out of the framework as it would differ significantly for engineering, business, and design students. And most of it would already be covered during their actual studies

Table 1: Major competence frameworks used to develop "low-tech" competence framework

EU JRC – Sustainability competences (Bianchi et al., 2020)	***Russo and Mueller – Social Innovation Education*** (Osburg and Schmidpeter, 2013)		***Innowise -Open innovation*** (Podmetina et al., 2018)		***Don Norman - Human Centred Design Principles*** (Norman, 2019)
	1. Knowledge	**2. Skills**	***1. Skills***	***2. Abilities***	
a. Systems thinking b. Values thinking c. Futures thinking d. Strategic thinking e. Integrated problem solving f. Interpersonal management g. Project management h. Self-awareness i. Topical knowledge	a. Drivers and Formats of Social Innovations b. Attracting Resources c. Cross-sector Social Partnerships d. Scaling and Replicating Ideas	a. Opportunity Recognition b. Understanding the Problem using Design Thinking c. Behavioural Change d. Social Value Measurement	a. Values thinking b. Communication skills c. Team-working skills d. Networking skills e. Problem-solving skills f. External collaboration skills g. Internal collaboration skills h. Entrepreneurial skills i. Multi-tasking skills j. Trust skills k. Negotiation skills l. IP management skills m. Leadership skills n. Virtual collaboration skills	a. Creativity b. Technology and business mindset c. Sharing ideas internally d. Adaptability and flexibility e. Strategic thinking f. Working in cross-functional teams g. Working an interdisciplinary environment h. Sharing ideas externally i. Working with different communities j. Managing collaboration processes k. Risk awareness l. Project management m. Failure tolerance n. New media literacy o. Cultural awareness	a. Understanding and addressing core problems b. Being people-centred c. Using an activity-centred systems approach d. Using rapid iterations of prototyping and testing

Table 2: Other competence frameworks considered to develop the framework

Shift Project – Training engineers for the 21st century (The Shift Project and Groupe INSA, 2022)	***Quelhas et al. – Sustainability competences*** (Quelhas et al., 2019)	***Castro-Sitiriche et al - Appropriate Technology Competences*** (Castro-Sitiriche et al., 2012)
a. Systems approach b. Interdisciplinary-based decisions or actions c. Historical understanding of Anthropocene and its consequences d. Analysis of dominant and alternative narratives e. Forward-looking approach f. Understanding of risks and uncertainties g. Mastery of multi-criteria assessment h. Product and process creation i. Management methods j. Utilising spheres of responsibility and collective management of technological choices k. Drawing inspiration from arts and culture l. Critical thinking	a. Systems thinking b. Normative competence c. Contextualization and future vision (anticipatory) d. Strategic competence e. Integrated resolution f. Collaboration g. Critical thinking h. Self-knowledge competence	a. Awareness of technology and its relationship to human progress b. Socio-technical system understanding c. Understanding the process of choice that is inherent to technological development and progress d. Understanding of appropriate technology and its relation to ethics and sustainability e. Cite and critique traditional and modern examples of appropriate technology f. Listening to and cooperatively working with members of a community in which a technological solution is proposed g. Be able to competently undertake employment or research in appropriate technology

Table 3: Mapping of the first competence areas to the different literature

Proposed Low-tech Competences	Respective competences from the different literature sources						
	EU-JRC	**Russo & Mueller**	**Innowise**	**Don Norman**	**Quelhas et al**	**Shift Project**	**Castro-Sitiriche et al**
Systems thinking	A	2B	-	C	A	A	B
Futures-thinking	C	-	-	-	C	E	-
Values-thinking	B	-	1A	-	B	D, G	C
Strategic thinking	D	2A, 2B	2E	A	D	C	A, D
Interpersonal management	F	1B	1B, 1C, 1F, 1G, 1M, 1N, 2F, 2G	-	F	B	G
Integrated problem-solving	E	1C	1E, 2J	-	E	I, K	D
Implementation/Project management	G	2D	2J, 2K, 2L	D	-	I	E
Intra-personal competence/Self efficacy	H	-	1I, 1M, 2M	-	G, H	L	G
People-centeredness and behavioural change	-	2B, 2C	1H, 2I, 20	A, B	-	J	F
Commons managements and open-source scaling	-	1A, 1D	1L, 2H, 2N	-	-	-	-

Table 4: Definitions of the first competence areas

Proposed Low-tech Competences	**Respective competences from the different literature sources**
Systems thinking	Be able to work in your field as part of a complex system that is closely related to other domains like your society, economy, and the environment; and to be able to think about your field on different scales from local to global
Futures-thinking	Be able to see and evaluate rich visions of the future in your field in the view of "low-tech" (sustainability, sober needs, and accessibility)
Values-thinking	Be able to understand the values that cause your actions and the actions of others; and be able to negotiate these values and targets in a context of conflicts of interests and uncertain knowledge
Strategic thinking	Be able to recognize the historical roots and barriers to change of unsustainability and societal challenges; and be able to creatively plan innovative experiments to test strategies in your field to address these issues
Interpersonal management	Be able to apply your 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
Integrated problem-solving	Be able to creatively solve problems in your field not only with using information from your field, but also information from other fields, and even new ways of thinking and knowing
Implementation/Project management	Be able to make a planned solution toward a "low-tech" vision in your field, to monitor and evaluate the process, and to address emerging challenges and make adjustments
Intra-personal competence/Self efficacy	Be aware of your own emotions, desires, thoughts, behaviours, and personality, as well as to regulate, motivate, and continually improve oneself drawing on competences related to emotional intelligence and social and emotional learning
People-centeredness and behavioural change	Be able to create and evaluate systems from the perspective of the users, including appropriate behavioural change techniques
Commons managements and open-source scaling	Be able to organise, scale, or mobilize resources for "low-tech" innovations and materials in accessible and viable ways
Topical knowledge	Have a good background in subject fundamentals that are relevance to the problem such as economics, basic mechanics, electronics etc.

Systems Thinking	Be able to work in your field as part of a complex system that is closely related to other domains like your society, politics, economy, and the environment
Values Thinking	Understand the historic roots and values that cause your actions and the actions of others; and be able to negotiate these values with others
Strategic & Futures Thinking	Be able to create and evaluate future scenarios in your field in the light of "low-tech"; and creatively develop strategies for these considering the risks and uncertainties (sustainability, sober needs, and accessibility);
Interpersonal Management and Problem Solving	Be able to engage, motivate, and creatively solve problems related to your field with people very different from you using information from diverse fields of study
Iterative Implementation for Impact	Be able to develop tangible ways to measure the impact of a system or product across different domains (technical, social, economic, political); and be able to use incremental iterations to obtain the desired impact
Behavioural Change & User-centeredness	Be able to create and evaluate systems from the perspective of the users, including appropriate behavioural change techniques
Viable Open-Source Scaling and Mobilization	Be able to organise, scale, or mobilize resources for "low-tech" innovations and materials in accessible and viable ways

Figure 2: Final description of low-tech competences used for the survey

3 Survey and Analysis

In this section, we discuss the survey results as well as the changes made to the competence framework following discussions with the members of the LT4Sustain project.

3.1 Survey Results and Analysis

From the surveys, we were able to test the perceived applicability of the competences developed to learning low-tech as assessed by teachers and students from engineering, design, and business schools. The survey was instrumental to ranking the perceived importance of the competence areas and in the case of any generally unimportant competences, excluding from the framework. In addition, participants also had the opportunity to include other competencies that they felt were missing from the work. Most of the other competence were along the themes of:

- Do-it-yourself, application, experimentation, tinkering
- Politics, policy
- Philosophy and deciding what is right
- Financial implication and competitiveness
- Understanding users and core needs
- Obtaining insights from unconventional places such as developing countries
- Convincing others of the problem and advocating for low-tech solutions

The survey, which was developed on Google Forms, was divided into five sections, and offered in English and French. The first section was to obtain the respondent's information, followed by a definition of low-tech. The next section verified the respondent's knowledge of low-tech and their perceived relevance of low-tech to their field of study or teaching. The last two sections covered the rankings of the various competences, and the resources that would ease the learning of these competences.

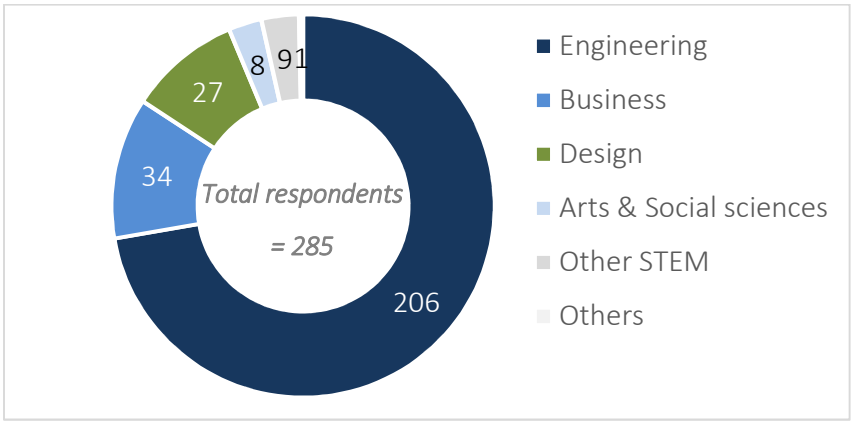


Figure 3: Field of study/work of survey respondents

The survey was filled by a total of 285 students from universities in Ireland, France, Belgium, and Portugal. 77% (220) of the respondents were current or recently graduated students. The rest of the respondents were either teachers or researchers. It was also notable that most of the respondents (>70%) studied or taught in the engineering domain as shown in figure 3. The next two highest domains represented were business and design schools. Notably, most of the respondents were already familiar with low-tech, with 55% saying that they had heard about lowtech, and its definition was the same as the definition we used for the project. This can be found in figure 4. In addition, 154 of the 285 respondents found that lowtech was very important to the world with most respondents also stating that lowtech was directly applicable to their work. This reported applicability was irrespective of fields of study or occupation.

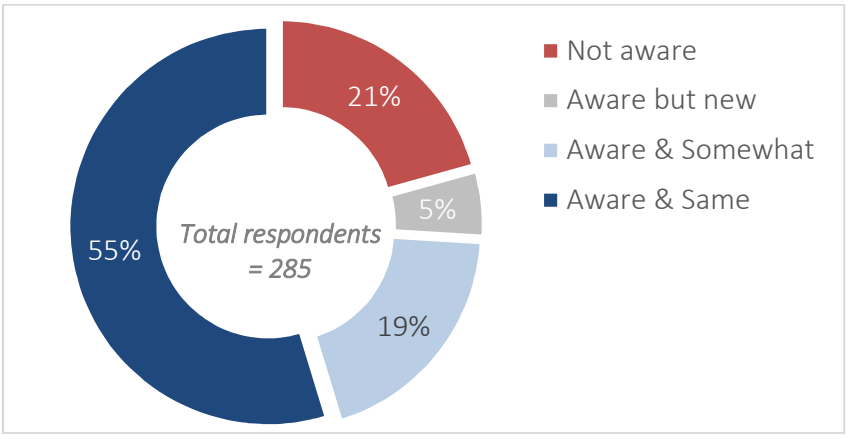


Figure 4: Awareness of the survey respondents of lowtech

When responding on the importance 0f the different competences, more than half of the respondents ranked all the competences as somewhat or extremely important. This ranking of importance was

seen to be higher for “Interpersonal problem-solving” and lowest for “Values thinking”. Regarding the resources, “Access to live application through interviews with practitioners and field trips” and “Conducting of practical projects” were very closely thought to be of great importance by respondents. While almost half of the respondents thought that the high contribution of low-tech courses to semester grades would be of no consequence to their learning of the competences. These results can be seen in figures 5 and 6. A deeper analysis was conducted to see if any of these results varied for people in different domains or occupations, however the results were found to be largely consistent. The analysis can be found in the appendices.

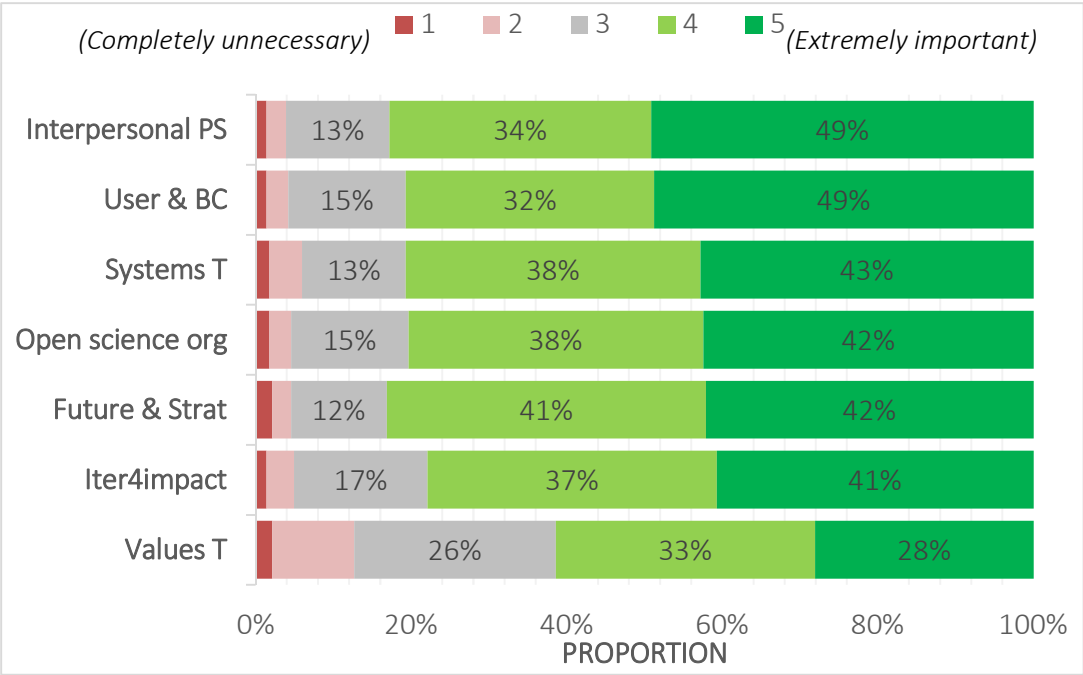


Figure 5: Perception of the importance of the different competence areas

Following the results, we can conclude that the competences would be relevant for most students, however, some competences might be perceived as more important than others. As such, it would be important to speak clearly about the relevance of all the competences. It would also be important to ensure that students could practice lowtech ideas as they were being taught.

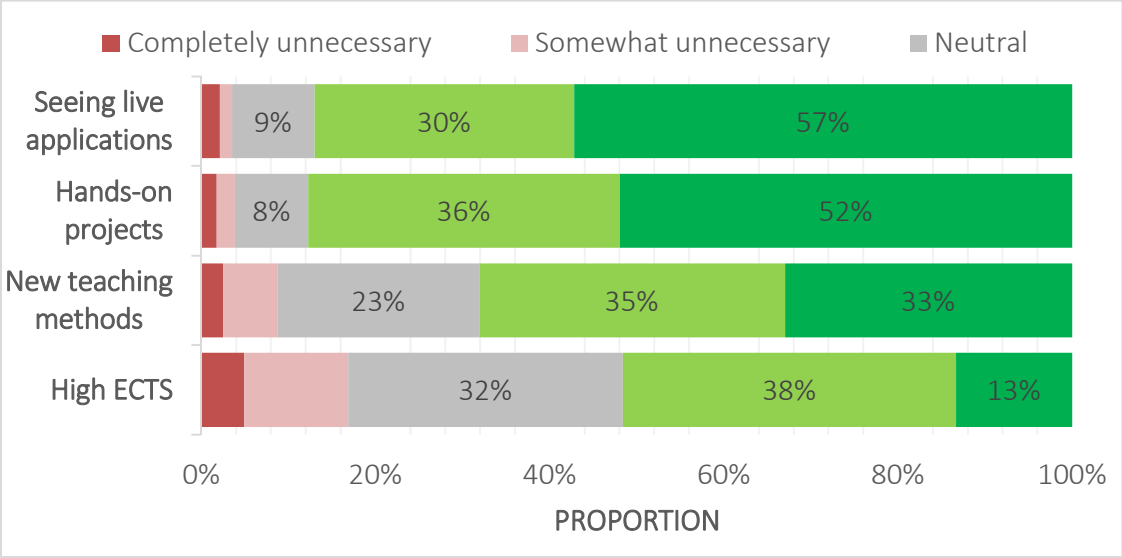


Figure 6: Perception of the contribution of various resources to improve low-tech learning

3.2 Adjustment of the competence framework with LT4Sustain

A transnational meeting was held from June 7 – 9, 2022. The meeting was held to align on the goals of the project and discuss some of the preliminary results of the project. The competences were also reviewed in more details by members of the LT4Sustain project. Team members were given a list of the competences and asked to say if any was missing and if any could be merged. There were two general pieces of feedback: 1) Certain competences had been left out and need to be included in the definitions of our competences, and 2) Even though, we had an exhaustive list of competences, there was a need to be more specific on the competences that we would teach.

These were the proposed changes to the competences:

- Include “Multi-disciplinary approach” as one of the competences
- Include “Ethical thinking and ethics” into the “Values thinking” competence
- Empathy should be included as a skill under “Interpersonal management”
- Include a competence for “Assessment and evaluation”
- “Design and Action” should be captured in one of the competences or as a competence on their own
- “Commons management and open-source scaling” should be adjusted because not all scaling even in the context of “low-tech” is going to be open-source

- Include a competence that focuses on the economic analysis and assessments
- Adjust “Futures thinking” to “Futures and Anticipatory thinking”
- Add design thinking as one of the competences

Following the additions of the group, the revised list of competences can be found below in Table 5 with the highlighted competences been edited following the meeting. Also, during this meeting, profiles of people and the respective competences that they would need was proposed. The former can be found in figure 7 below while the later can be found in the appendices.

With that lowtech competences had been defined and refined with extant literature. These competences have also been found to be relevant to student and teachers in higher education. Next, the lowtech philosophy will be tested with a technical area to show that it has some value to research and industry.

Table 5: Adjusted low-tech competences following transnational meeting

Adjusted Low-tech competences	Modified descriptions of competences
Systems thinking	Be able to work in your field as part of a complex system that is closely related to other domains like your society, economy, and the environment; and to be able to think about your field on different scales from local to global
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
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
Strategic thinking	Be able to recognize the historical roots and barriers to change of unsustainability and societal challenges; and be able to creatively plan innovative experiments to test strategies in your field to address these issues
Interpersonal management	Be able to apply your 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
Multi-disciplinary problem-solving	Be able to creatively solve problems in your field not only with using information from your field, but also information from other fields, and even new ways of thinking and knowing
Implementation (Design, Action & Assessment)	Be able to use design thinking in an incremental iterative approach to create impactful solutions and develop tangible ways to evaluate the impact of solutions or systems across various domains (economic, social, environmental)
Intra-personal competence/Self efficacy	Be aware of your own emotions, desires, thoughts, behaviours, and personality, as well as to regulate, motivate, and continually improve oneself drawing on competences related to emotional intelligence and social and emotional learning
People-centeredness and behavioural change	Be able to create and evaluate systems from the perspective of the users, including using appropriate behavioural change techniques when needed
Commons management and solution scaling	Be able to organise, mobilize, and scale resources for "low-tech" innovations in accessible and economically viable ways that are well adopted to the local context
Topical knowledge	Have a good background in subject fundamentals that are relevance to the problem such as economics, basic mechanics, electronics etc.

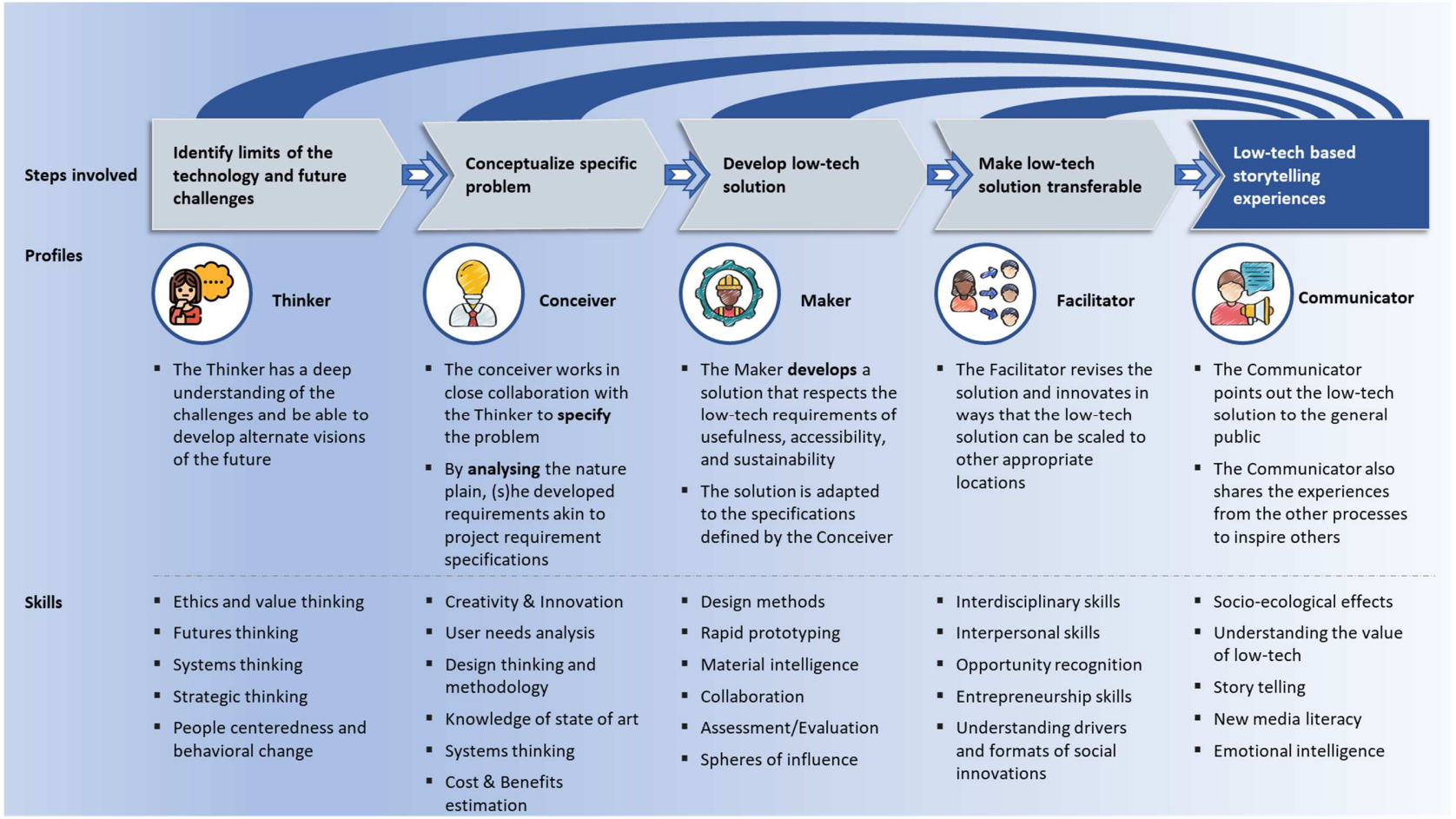


Figure 7: Conception of low-tech profiles and their competences

4 Conclusions

This work has shown that the conception of low-tech competences as way to teach sustainability is perceived as useful by stakeholders and is also practically useful in technical areas. In the context of education, the rigorous definition of a competence framework as well as the positive responses of teachers and students show that this is a valid area of interest. The survey results highlight the importance of practicality as a factor that would encourage learning about lowtech. As such, there needs to a premium placed on showing practical solutions such as the lowtech analysis of balancing solutions displayed in the second part of the report when integrating low-tech into the curriculum of students.

4.1 Limitations of this work and future works

The work on the education aspects was mostly based on students in engineering schools, as most of the partners are engineering schools. For future work, a more comprehensive survey can be carried out in more countries with more participants from business and design schools. Following the identification of the competence framework and the profiles of LT users, the next steps would include identifying resources that can give students these competences and developing them where required. An impact of students applying lowtech to their careers can also be investigated following the successful building of these competences.

References

Akubue, A., 2000. Appropriate Technology for Socioeconomic Development in Third World Countries. J. Technol. Stud. 26.

Bianchi, G., European Commission, Joint Research Centre, 2020. Sustainability competences: a systematic literature review.

Bihouix, P., 2014. L'âge des low tech: vers une civilisation techniquement soutenable, Anthropocène. Éd. du Seuil, Paris.

BONJEAN Anne-Charlotte, FANGEAT Erwann, ADEME, FORGET Astrid, FUSTEC Alan, HABE Camille, JAEGER Romain, MOIROUD Loraine, MORALES Eloïse, Goodwill-management, CHABOT Clément, Lowtech Lab, 2022. État des lieux et perspectives des démarches "low-tech." ADEME.

Castro-Sitiriche, M., Papadopoulos, C., Frey, W., Huyke, H., 2012. Sustainable wellbeing education in engineering, in: 2012 IEEE International Symposium on Sustainable Systems and Technology (ISSST). IEEE, Boston, MA, pp. 1–6. https://doi.org/10.1109/ISSST.2012.6228005

Ceschin, F., Gaziulusoy, I., 2016. Evolution of design for sustainability: From product design to design for system innovations and transitions. Des. Stud. 47, 118–163. https://doi.org/10.1016/j.destud.2016.09.002

Illich, I., 1973. Tools for Conviviality. Harper & Row.

Low-tech, 2022. . Wikipédia.

Low-tech Lab – Les Low-tech : l'innovation utile, accessible et durable. [WWW Document], 2022. URL https://lowtechlab.org/fr/la-low-tech (accessed 4.25.22).

Norman, D., 2019. The Four Fundamental Principles of Human-Centered Design and Application [WWW Document]. jnd.org. URL https://jnd.org/the-four-fundamental-principles-ofhuman-centered-design/ (accessed 4.26.22).

Norman, D., 2013. The design of everyday things: Revised and expanded edition. Basic books.

Osburg, T., Schmidpeter, R. (Eds.), 2013. Social Innovation: Solutions for a Sustainable Future. Springer Berlin Heidelberg, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-36540-9

Oxford Advanced Learner's Dictionary, 2022. low-tech adjective - Definition, pictures, pronunciation and usage notes | Oxford Advanced Learner's Dictionary at OxfordLearnersDictionaries.com [WWW Document]. URL https://www.oxfordlearnersdictionaries.com/definition/english/low-tech (accessed 5.17.22).

Philippe BIHOUIX, Hugues SIBILLE, Marie VERNIER, Nikola JIRGLOVA, Florian LABOULAIS, 2022. POUR DES MÉTROPOLES LOW-TECH ET SOLIDAIRES. Le Labo de l'ESS.

Podmetina, D., Soderquist, K.E., Petraite, M., Teplov, R., 2018. Developing a competency model for open innovation: From the individual to the organisational level. Manag. Decis. 56, 1306–1335. https://doi.org/10.1108/MD-04-2017-0445

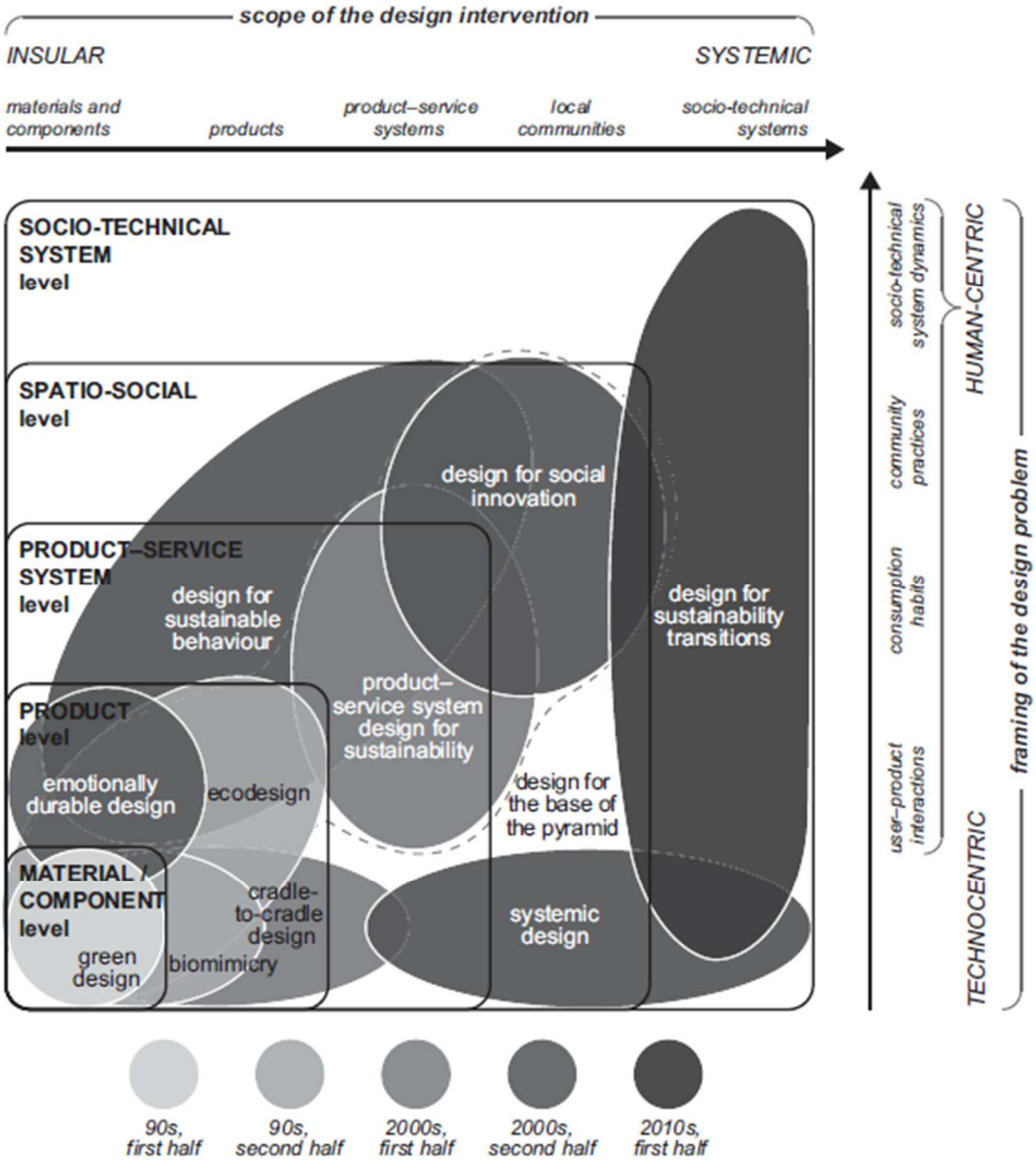
Quelhas, O.L.G., Lima, G.B.A., Ludolf, N.V.-E., Meiriño, M.J., Abreu, C., Anholon, R., Vieira Neto, J., Rodrigues, L.S.G., 2019. Engineering education and the development of competencies for sustainability. Int. J. Sustain. High. Educ. 20, 614–629. https://doi.org/10.1108/IJSHE-07-2018-0125

Schumacher, E.F., 1979. Small is beautiful: une société à la mesure de l'homme. Contretemps/Le Seuil.

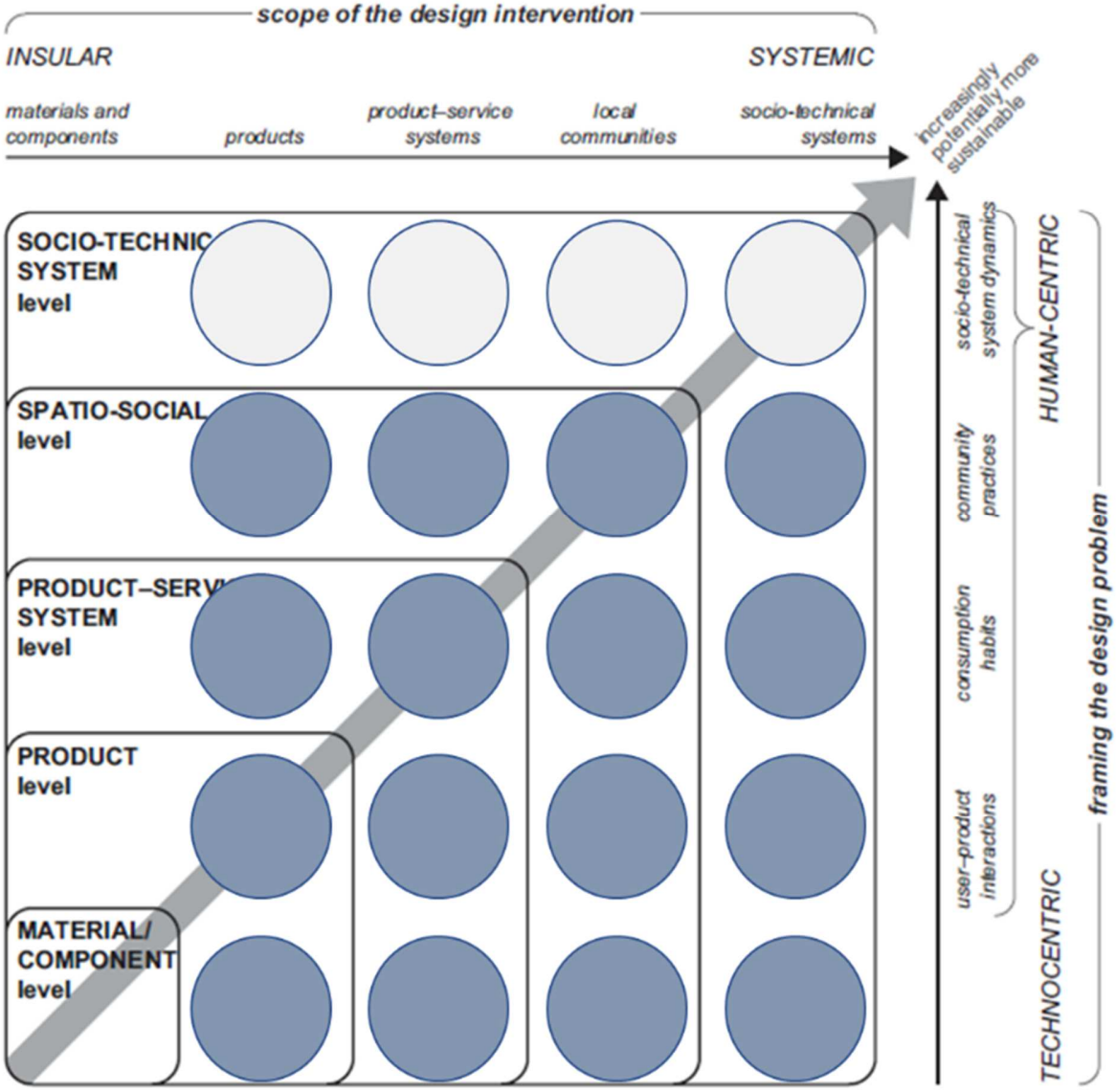
The Shift Project, Groupe INSA, 2022. FORMER L'INGÉNIEUR DU XXIe SIÈCLE: Pour l'intégration des enjeux socio-écologiques en formation d'ingénieur (Vol 1 - Manifeste). The Shift Project.

Appendices

Appendix 1: Framework for design for sustainability



Proposed placement of low-tech in DfS framework



Adjusted 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