Innovation Ecosystem for women makers through textiles labs and the shemakes.eu approach

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Abstract

The drive for change is transcending all layers of society. The call for more social justice spreads throughout research, policy, industry and civil society. Practices are flourishing from the individual to the territorial level, creating heterogeneous communities of practitioners. People are juggling with many forms of innovation to reshape in parallel many dimensions of systems, looking for more equity, sustainability, and comfort.

It has become necessary to reflect at the innovation ecosystem level, to better understand the current dynamics of these changes and better frame, design and evaluate the interventions we are co-creating and the impacts we are generating by acting in our close environments.

In this paper, we present the shemakes.eu project as a fertile ground for the maker movement and associated partners to reflect on gender gaps, proposing a series of interventions that raise awareness and empower women in lab environments, in the Textile and Clothing industry, and more widely in Science, Technology and Innovation (STI) policy frameworks.

After giving a short overview of our research methodology based on action research, we present our work in four parts, starting with the contextualisation of the gender gap at different scales, mapping the emerging shemakes.eu innovation ecosystem, proposing a series of interventions through labs-based activities and projects, and reflecting on key lessons learnt and future actions for the (women's) maker movement.

Keywords

Gender, textile industry, woman makers, distributed education, innovation ecosystems, maker movement

1 Introduction

Gender has different dimensions and facets, which go beyond women and the implications of identity, biological, geographical and social differences, and new perspectives that emerge through a world characterised by humanity's changing crises and developments. Indeed, the United Nations Sustainable Development Goal n.5 is Gender Equality ('Gender Equality and Women's Empowerment', 2021), where inclusion and diversity in a global entrepreneurial context can play a fundamental role in increasing gender equity. One of the most critical aspects is to build an understanding as a maker, as a woman and a contributor to change in the world, and generating an innovation ecosystem that can bridge the gap, preventing it from growing. Although many efforts have already been made, there are still many unsolved

issues, particularly the integration of women and young people to become future innovators and provide them with the support they need to succeed. In past crises, inequity has been perpetuated. Therefore, innovation plays a key role in addressing and solving societal challenges to guarantee that this phenomenon is not repeated. In the current landscape, it is not clear whether innovation contributes to reducing the gender gap or whether we need to reduce the gender gap to have a more innovative ecosystem. Most innovation can become a driver to reduce the gender gap, but it depends mainly on how innovation is developed and owned and the degree to which it contributes to the goals of the twin transitions "digital and sustainable", where there is still aminority of women (Gabriel & Carvalho, 2021).

Therefore, it is vital to understand the meaning of innovation and consider innovation in all its dimensions, not only in the technological but also the scientific, institutional, and social dimensions, to integrate an innovation ecosystem. Then we can address the negative impacts deriving from the minority participation of women in technology-related initiatives.

This is particularly relevant, for the present paper, for the panorama of the Maker Movement[1] and FabLabs, where the majority of activities is related to computer science, mechanical engineering and other areas where there is still a predominance of men in roles ranging from education to lab management and open innovation investment.

Accompanying the efforts of Fabricademy (Pistofidou & Raspanti, 2021) in a European context, the TCBL (*TCBL Foundation*, 2021) Project focuses on the value created through the knowledge put into the development of products and a fairer working atmosphere in the context of textiles and clothing.It has provided new insights on the experience of women in the textile industry, introducing open innovation to a new lab typology: textile labs.

This paper builds on these experiences to propose a reflective analysis based on the ongoing action research in the EU-funded shemakes.eu[2] project. The goal of shemakes.eu is to promote gender parity through initiatives in the textiles and clothing sector by empowering future female innovators of a sustainable fashion industry through inspiration, skills and networks. In the following paragraphs we introduce the process of understanding and defining the innovation ecosystem in shemakes.eu, presenting the different layers and the complexity of the perspectives on the design approach as developed during the first seven months of the project.

2 Action-research in the shemakes.eu project

shemakes.eu is a two-year project responding to the Horizon 2020 Call (*Innovators of the Future: Bridging the Gender Gap | Programme | H2020 | CORDIS | European Commission*, 2021) in promoting a better integration of society in innovation and science through the development of the opportunity ecosystem bridging the gender gap. The project aims at defining an innovation ecosystem of textile and FabLabs to equip women entrepreneurs in textiles and clothing with inspirations, skills, networks. In its approach, shemakes.eu builds on and integrates two existing innovation ecosystems: Fabricademy: Textiles and technology academy and TCBL. The integrated ecosystem in shemakes.eu aims at raising awareness of the gender gap in innovation and encouraging collaboration among schools, science and technology museums, foundations, start-ups, etc., while involving young people in the innovation ecosystem. In terms of impact, shemakes.eu aims to increase the number of female innovators and explore how to better match skills to jobs in Europe.

[1] A definition of the Maker Movement emerged from a renewed interest in the physical side of innovation (Voigt et al., 2016), or the next digital revolution as it enables personal fabrication on people's desks (Gershenfeld, 2007). In a broader sense the make movement defines the community of makers, the FabLabs maker spaces, hackerspaces, tinkering, that are focused on learning by using mostly digital tools and democratising tools, knowledge and sharing in community.

[2] The shemakes.eu project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006203. https://www.shemakes.eu/

2.1 Research framework and methodology

Through the objectives of shemakes.eu we have approached the issue through qualitative research. In the following, we describe the events and dynamics developed through three types of research: **a) Desk Research** towards working out an innovation methodology based on already established activities of the baseline ecosystems and defining opportunities for advancement; the term “ecosystem” has been explored in a literature study. **b) Co-creation workshops** that facilitate the dialogue among stakeholders built around a common purpose regarding the gender vision, learning paths, innovation services and reputation management. Furthermore, **c) Labs peer-learning** environment, in which the project’s seven labs created an interactive environment to exchange knowledge and further develop the activities. This process allowed us to create a different perspective and develop tools from educational to entrepreneur materials, surveys, interviews, and project outputs. The following section will present how these methods have been applied to describeand build a comprehensive approach in which the innovation ecosystem and its interactions are identified in the "shemakes.eu innovation ecosystem mapping".

2.2 Innovation ecosystems, through iteration of sketching concepts andinterdependencies

An ecosystem in its natural science definition reflects a collection of different species that coexist and relate to collaborate all together. According to the previous definition, an innovation ecosystem is the interaction of the context, actors, relationships, and tools of all the elements that make this atmosphere optimal to generate an innovation environment. An ecosystem is alive and changing; it describes its complexity in building the actors pathways, strategies and dependencies between themselves and other ecosystems to generate their growth. A map of the shemakes innovation ecosystem has been co-constructed through various iterations. Inspired by the approach of (Granstrand & Holgersson, 2020), the shemakes ecosystem has been mapped out as a set of concepts, values, and interrelationships between and within ecosystem actors, artefacts and activities.

Building on that approach, this paper follows four steps: a) setting up the complex situation of the gender gap at different scales; b) mapping the innovation ecosystem; c) proposing a series of interventions through labs based activities and projects; and d) reflecting on key lessons learnt and future actions for the maker communities.

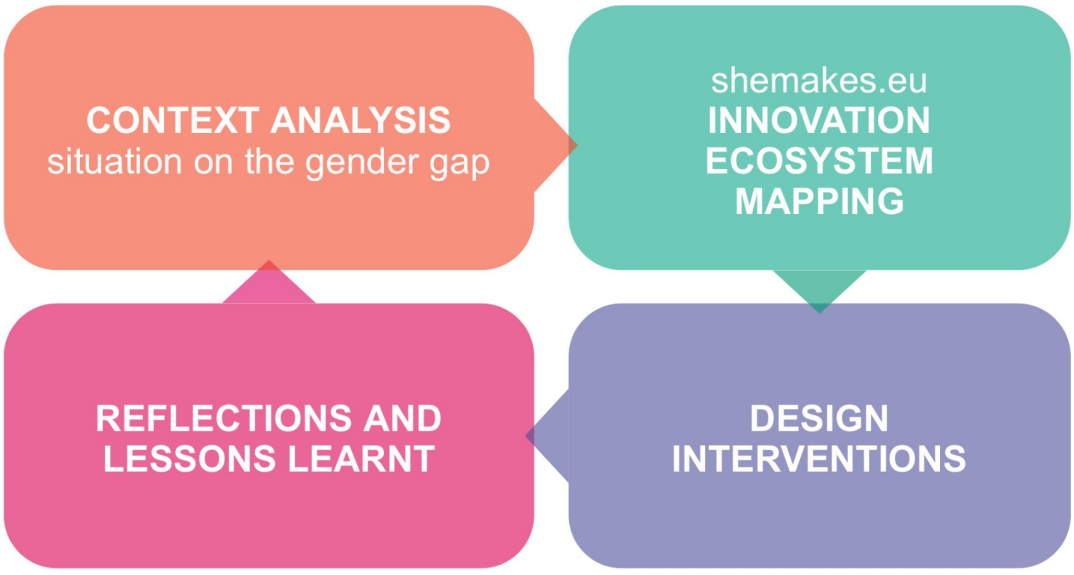

Figure 1: Methodology approach shemakes.eu

Setting up the situation on the gender gap: innovation, the textile industry and themaker movement

Gender as a transversal dimension in innovation ecosystems

The terms innovation and innovation ecosystem have been widely adopted over the last 15 years, based on an initial understanding by Joseph Schumpeter (‘Joseph Schumpeter’, 2021), the founder ofinnovation

theory. Following Schumpeter, innovation is often understood within a business and strategic context, often overlooking other inherent dimensions such as the political and institutional aspects of innovation and innovation ecosystem (Granstrand, 2020).

To better represent the terms' multiplicity, we use the following definition of innovation ecosystems by Granstrand et al. within the scope of this work: "*An innovation ecosystem is the evolving set of actors, activities, institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.*"

Initially, the work of Brush et al. (Brush et al., 2019), Hughes et al. (Hughes & Yang, 2020) and Antonelli et al. (Petruzzella et al., 2020) on (gendered) innovation ecosystems was examined and combed with Mattila's work on network activities as success factors and well-known models such as the innovation helixes. In the following (Figure 2), we provide an overview based on the authors' references previously mentioned, highlighting a set of key components of innovation ecosystems. For example, these components can be grouped by social, cultural and material categories. Practised culture, narratives and visibility, and education and training opportunities can be acknowledged as crucial cultural success factors. In contrast, network activities and relations between ecosystem actors relate to social success. This links loosely with the innovation helix model, e.g. by highlighting the interactions with governmental, scientific, public and industrial entities and the resonance with environmental issues. The material category includes infrastructural and financial support and opportunities, acquisition (access to bidding processes, human capital and a client base).

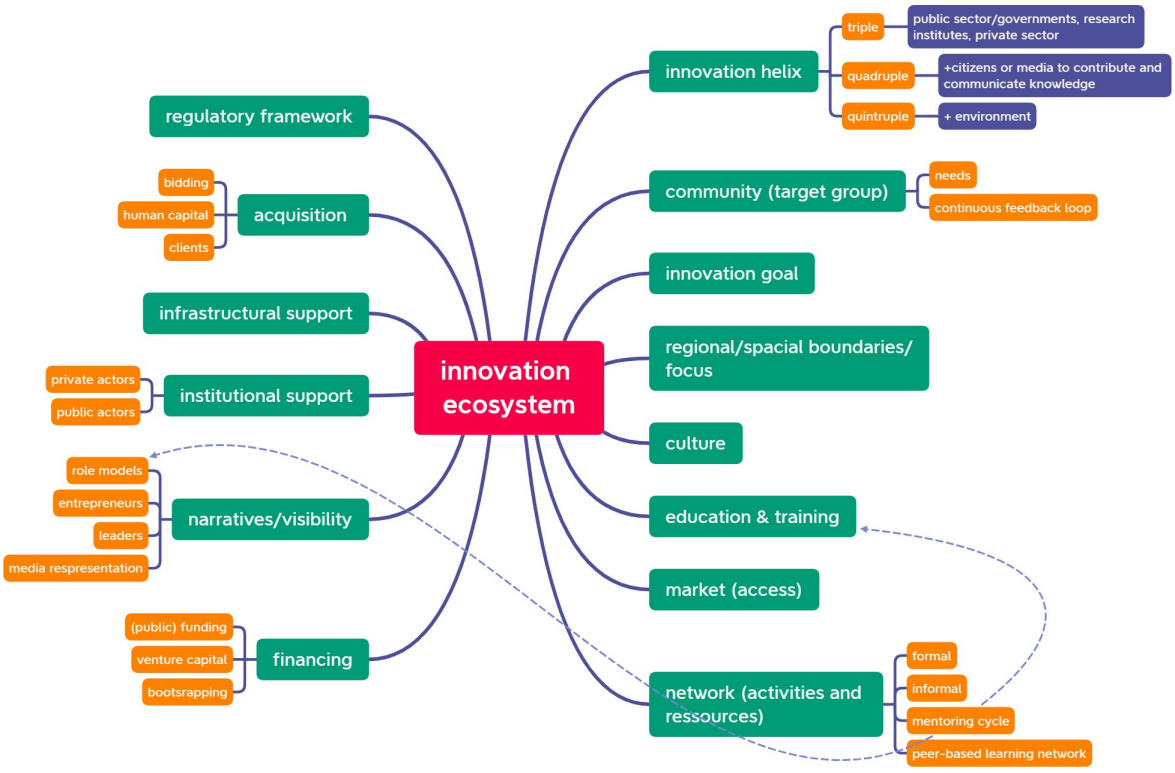

Figure 2: Innovation ecosystem components by literature definition

The innovation process in shemakes.eu is oriented towards understanding the current state of women and gender equality in the T&C industry, how they address this issue and in which directions, how aware they are of these inequalities or how much effort they put into solving this problem. Furthermore, we aim to understand the inequalities in different areas of education and production atthe industrial level and the dynamics that take place in FabLabs, how these two environments differ, and how they can be connected to make an environment that enables new opportunities.

As a complex and non-linear ecosystem, shemakes.eu generates value in networks of co-creative collaboration. The project aims to integrate all relevant types and dimensions of innovation and thus to build on the key actors in the framework of the quadruple helix (industrial, institutional, scientific and

socio-technological interactions). This approach underlines the importance of actively integrating the public sphere and the role of society as a major actor in national systems of radical change, thus covering a broad scope of innovation. Other thematic perspectives aligned with the programme's objectives are the sustainable transition (green transition) and a third transition of diversity and inclusiveness that represents a collaborative community and engagement towards creating an optimal innovation atmosphere.

The gender dimension in innovation ecosystems is often considered as transversal: In particular Brush refers to the women's environment as one of five influences on success. (Brush et al., 2019) coined a "5M" framework for this, consisting of "money", "management", "markets", "motherhood" (family context) and the "macro/meso environment" (considerations beyond the market). Whereas money and market are self-explanatory as necessary requirements for entrepreneurial success, management targets the human and organisational capital, and motherhood describes the influence of the female innovator's family and household environment (assumed to have a larger impact on women than men). Finally, the macro/meso environment includes social and cultural influences beyond pure market forces, like normative expectations and public representations of female innovators.

Gender framework innovation ecosystems in the shemakes.eu environment

Shemakes.eu evolves in the context of three interconnected environments acting at different scales with various stories, dynamics and gender perspectives in the context of a) the European political ecosystem of Science, Technology and Innovation, b) the Textile and Clothing industry, and c) the Maker Movement.

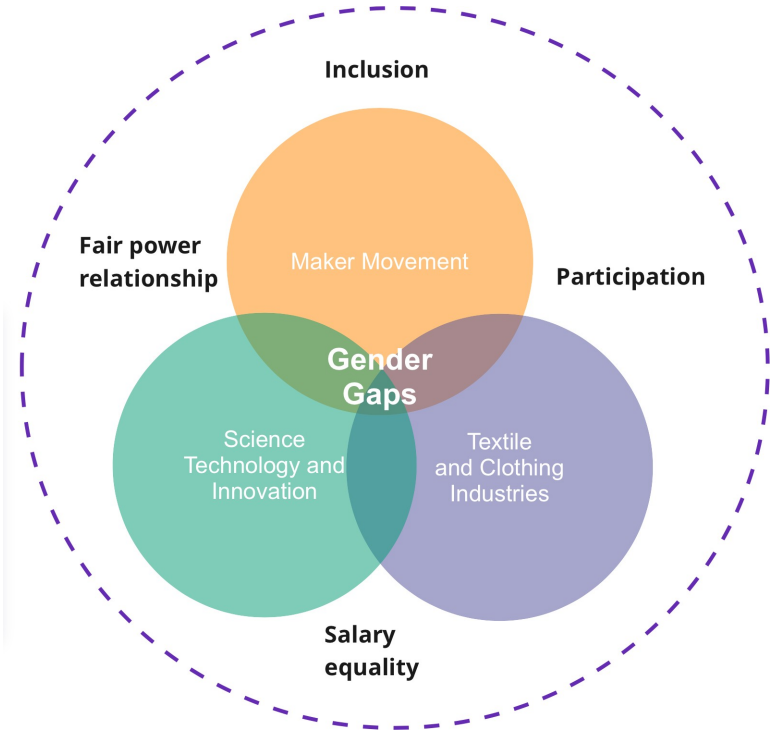

Figure 3: Gender framework for innovation ecosystems

From textiles and clothing to science, technology and innovation (STI)

Exploring the causal roots of the gender pay gap in STI sectors led to identifying new opportunities for action, especially in the proactive search for revisiting, diversifying and reinforcing the skillset of the women that will shape the future of the textile and clothing sector.

Textiles and clothing are in the socio-cultural DNA of women, most clearly if we talk about women's role in technology; indeed, the first effort to validate women's wage labour took place in the textile industry in the United States. In this sector, the work of women was appreciated for their manual skills and *gender-sensitive approac*h (Shujun & Ferrara, 2020). Similarly, the most relevant and impactful technological

inventions for women's lives are the power loom for weaving and sewing machines. These innovations had a disruptive impact on the modernisation of the world, contributingto the birth of the textile and clothing industry globally. The sewing machine, the first personal home machine, was a means for both creative and political expression and labour independence. Moreover, it made it possible for the end user to move from design to production. In this context, the craft sensibility of women and maker culture is considered but underestimated in economic and business terms.

Later in industrialisation and after great crises[3] in the male labour force gap, women played an important role, although not necessarily well paid. In a certain way, they confronted a new place for women in society and had a great commitment to social responsibility. The Bauhaus movement, withdesigners like Gunta Stölzl and Anni Albers in 1931, encouraged women to take a novel look at the technology of expression in textile products (Katsarova, 2021).

Today in the textile and clothing (T&C) sector, women represent nearly 70% of all employees (*EURATEX*, 2020) in the sector. However, women in particular are working as sewing machinists – a very low paid occupation - whilst men tend to be found in the higher paid management roles.[4] The T&C Industry in Europe consists of 170,000 enterprises, primarily micro, small and medium-sized, employing more than 1.7 million people. Here, women have traditionally been confined to marginal roles, such as sewing garments in garment workshops, while men tend to take on management roles,work with the heavy machinery, and chair the multinational fashion conglomerates. Yet the sector is under enormous pressure to innovate: each year, it generates around 1.2 billion tonnes of CO2, while10% of the 100 billion garments produced go straight to landfill. Furthermore, the garment sector is connected to many other industries, with its diversity of textile materials, manufacturing systems, transport and logistics, relations with agriculture, etc. Therefore, innovations that can be addressed systematically are likely to have a spill-over effect with a significant impact.

Meaningful changes in social responsibility can be seen in the example of the global Fashion Revolution movement that reflects on the climate crisis and the demeaning work in fashion to try to improve labour conditions and reduce the socio-environmental impact in the future. According to theBoF McKinsey & Company report *The State of Fashion 2019* "Younger generations' passion for social and environmental causes has reached critical mass, causing brands to become more fundamentally purpose driven to attract both consumers and talent". Many women are involved in this movement as *advocates of change,* influencing the working conditions of those making clothes in extreme poverty or unfair conditions (*Exploitation or Emancipation?*, 2015) .

Other trends at the intersection of biology, design, art and digital fabrication have led to the use of specific technologies and unique expressions, with the creation of new aesthetics in the designs of Iris Van Herpen (Figure 4) and Nery Oxman (*Neri Oxman*, 2021), exploring novel interventions in the field of T&C design and ultimately in innovation.

Emerging communities, projects and niches are transforming the internal practices with fashion technologies and circular and sustainable design both in art and design schools, in textile and fashion companies, and in distributed networks like (*Fashiontechalliance*, 2021), (*Fashion-Tech Higher Education | E4FT*, 2021), TCBL or the original work of Fabricademy.

In a contemporary vision, women participation was raised in different industrial fields, including in communication and technology. Today, in STI policies, there is a strong focus on addressing the gender gap by increasing the presence of women in STEM (Science, Technology, Education and Mathematics) education and entrepreneurship. In a sense, the predominance of scientific fields can be seen in the EU Prize for Women Innovators award. However, additional efforts are needed to apply gender mainstreaming to broader innovation processes and industrial sectors, where the gender gap can be addressed by increasing the added value of currently low paid female-dominated activities.

[3] The First World War acquired a central place in the birth of the *new women, a challenge to the traditional roleof women as homemakers in the private sphere* (Shujun & Ferrara, 2020)

[4] shemakes.eu theory of change workshop, deliverable Evaluation Plan

Figure 4: The maison of Iris van Herpen, Haute Couture (*The Maison of Iris van Herpen*, 2021).

Gender gaps and strategies in the Maker Movement

FabLabs aspire to be inclusive co-working spaces for people from various cultural and professional backgrounds, age groups and genders (Marić, 2018). Thus, the Maker Movement, developed in such labs, has a significant potential to improve gender equality, as younger generations bring social change to FabLabs and break stereotypes around implementing practices (Eckhardt et al., 2021).

Despite expanding to many territories and activating technological democratisation, there are still stereotypes and cultural biases in the maker environment. Although maker spaces promote equal access, studies show that the maker movement is characterised by gender disparity due to stereotypes of the male bias towards technology and the lack of female role models (Loose, 2020). Loose´s thesis argues that women makers show greater participation and sensitivity towards sustainable practices. Several women leaders in the Fablab environment have presented diverse initiatives through science and sustainable awareness with hands-on bio-fabrication, circular economy, and sustainable industry 4.0 activities.

The last decade has seen an increase in the participation of women in the maker movement, especially in the field of wearables, with the introduction of tools of interaction such as Lilypad[5] (Buechley et al., 2008), Limor Fried's electronics hobbyist company Adafruit industrie (‘Limor Fried’, 2021) to Kobakant's open resources “How to Get What you Want” (Satomi & Peter-Wilson, 2021), making the access of Wearables and tutorials for open source hardware and software more inclusive and easy to get started with.

The importance of combining textile craft skills such as sewing, embroidering, knitting and weaving with embedded electronics provides an inclusive understanding to other fields such as engineering and computer science. In recent years, the participation of women in STEAM (Science, Technology, Engineering, the Arts and Mathematics) areas, biotechnology, and textiles has increased through a more diverse offer with programmes such as Fabricademy (Pistofidou & Raspanti, 2021), Poderosas (Robles, 2021),[6] and Fab Woman (Barriga, 2021),[7] which have promoted diversity and the call for women interested in creative areas of design and fashion as well as the implementation of new digital manufacturing technologies.

[5] Lilypad: Microcontroller board from the Arduino Family used mostly for projects in sewing and electronics.

[6] Poderosas is an educational program led by FabLab Leon, focused on K-12s girls to empower more girls in using technologies through learning by doing.

[7] Fab Woman is a network of women working in Fablabs on different content around sustainability, fashion , Industry 4.0 led by the Latinoamerican FabLabs FABLAT.

However, Okerlund et al. (2018) highlights the influence of stereotypes, mainly if they are constructed as a strategy to include women: "On the one hand, a makers fashion show could be seen as feminist in the sense that it brings a traditionally feminised craft into the realm of making. On the other hand, it could also be seen as anti-feminist because fashion is traditionally about the subjection of female bodies." In this sense, the authors suggest giving more importance to creating the conditions for a gender-open and enabling environment.

Still, there are efforts to be made for the equal representation of gender, whereby leadership roles engage women in innovation and are opening up the debate on inclusiveness and diversity in Maker Spaces (Voigt et al., 2017).

In the following table, you can find a comparative analysis of the trends, gender issues, and positive examples for the three main contexts considered here: T&C, STI, and maker spaces.

Scales	Change potentials	Gender Gaps	Examples of good practice
Textile and Clothing Industries	Historical industrial sector under strong pressure to innovate and high potential to be transformed by disruptive digital technologies and sustainability challenges.	Gender pay gap andstereotypes	Fashion Revolution (*Women Archives*, 2021), L´Oreal Unesco (*For Women in Science*, 2021) , Gender Smart prize, (*Gender-SMART*, 2021), E4FT (*Fashion-TechHigher Education*, 2021)
STI environments	Raising awareness, fostering collaborative innovation and pushing for more inclusivity and participation of citizens in RRI at the EU level.	Lack of girls and women in technological field from education to industries Problems of violence	Global sustainable Goal(*THE 17 GOALS | Sustainable Development*,2021) Hypatia ('Hypatia Project - Expect Everything', 2021), (OpenScienceHub, 2021), Siscode (SISCODE, 2021.), Equal4Europe,Global Digital Women, DISCO, Genderplusnet
Maker Movement	Glocal community-driven spaces centered around different kinds of making, open source culture and the democratisation of technologies.	Over-representation of men and lack of role-models in labs. Maker spaces suffer from "stereotypes and culturalbiases" Higher sensibility to sustainable practices forwomen Lack of inclusivity policies in makerspaces	Fab charter (*Fab Foundation – The Fab Charter*, 2021) Generative interventions for equity Inclusive Atlas of the Future (*AoF*, 2021) manifesto from Pop-Machina project (*Pop Machina*, 2021) Fab Care Statement (*FabCare*, 2021.) (*Manifesto*, 2021) E-textiles and wearables communities, (*HOW TO GET WHAT YOU WANT*, 2021) Attraction of fashion designers for digital fabrication tools. Marketing and media fashion come with digital tools and radically new approaches to fashion production.

Table 1: Synthesis view of the gender gaps framed through the shemakes.eu project

2.3 Mapping the shemakes innovation ecosystem

As mentioned above, an ecosystem is a constantly changing one. Thus, to describe the outreach and constraints of the emerging shemakes.eu ecosystem as it has been developing in the first months of the

project and in the collaboration of the partners, we have mapped actors, values, and activities of the ecosystem starting from the questions:

- How do the Fabricademy and TCBL ecosystems work?
- How can we promote the integration of these existing ecosystems?
- What are the driving forces that lead shemakes.eu to create innovation?
- Does this ecosystem distinguish itself in being innovative and, more in depth, what drives the development of this ecosystem?

Finally, the further comprehension of interactions and relationships in each of the six main work packages (Gender Vision Learning Paths, Innovation Services, Reputation Management, Evaluation, Communication) contributes to developing and establishing the innovation ecosystem.

We started by mapping the two existing ecosystems in shemakes.eu (Fabricademy and TCBL) for which the project aims to build a bridge and develop a common vision of the values, actors and activities involved in the textile and fashion sector.

Fabricademy (Pistofidou & Raspanti, 2021)

Fabricademy is a transdisciplinary course that focuses on the development of new technologies at the intersection of textiles, bio-technology and digital fabrication. Fabricademy was born in 2016 as a collaboration between the different networks (TCBL network, Waag, Fabtextiles, later extended to the FabLab network globally), expanding peer-based educational networks in the belief that current, future and emerging scenarios for the textile and fashion industry require hybrid multidisciplinary profiles with digital competencies. For five years now, the Fabricademy programme has provided several examples of how to reinterpret digital manufacturing in areas such as human interaction, materiality, eco-design, bio-design, performance, smart textiles, health technology, arts and new fashion expressions, among others. As a result of this initiative, connections with industrial and research ecosystems have been initiated through Fabricademy's digitisation and sustainability practices. The focus areas of this programme are shown in greater detail in Figure 5. as a program that mainly functions within the FabLab Network. Fabricademy brings gender diversity and inclusion to the maker movement: a total of 116 women & 29 men have attended the program in 45 locations, with ages ranging from 17 to 65 and 35 different nationalities. One of the goals of the FabLab network has been to break the stereotypes that technology is made by men and create a more comfortable entry point for tech explorations by women.

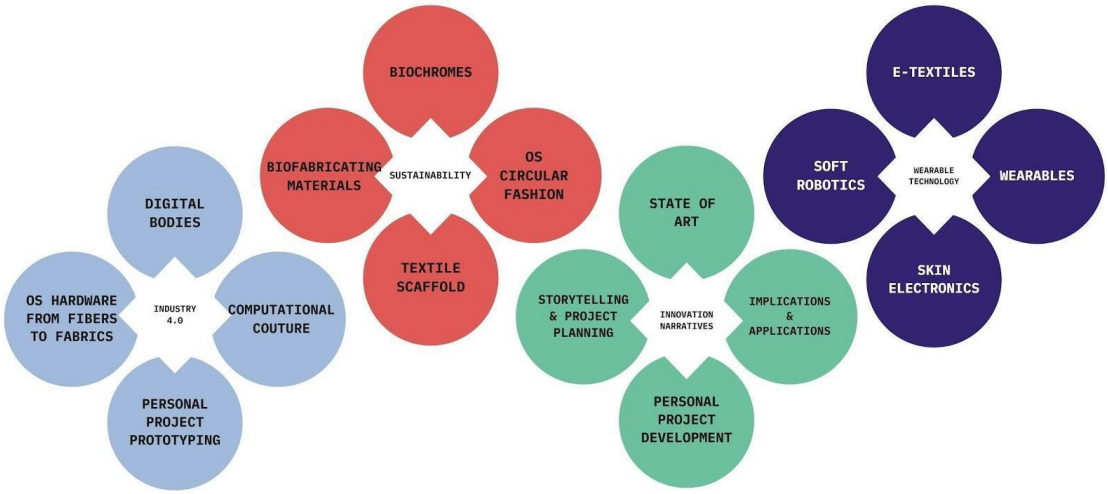

Figure 5: The Fabricademy program's research agenda (Pistofidou, 2021)

Textile & Clothing Business Labs TCBL (TCBL Foundation, 2021)

Complementing the effort to explore new perspectives on the T&C sector, TCBL is a value-based innovation community built up during a four-year Horizon 2020 project of the same name. Its multi-faceted business ecosystem comprises sector enterprises, innovation labs, service providers and advisors

working together to transform the Textiles and Clothing industry. The common objective is to build alternative, circular and sustainable paths to counter over-production and diminishing value.

Conceptualised within a collaborative bottom-up network of laboratories and businesses, the TCBL lab model has three levels: a set of common principles, the individual lab essence characterisation, and the set of lab activities. This framework is open to a wide variety of lab types - from materials research centres to social sewing factories - all sharing the 7 principles that shape their modus operandi, without limiting their individual nature (Table 2 and Figure 6).

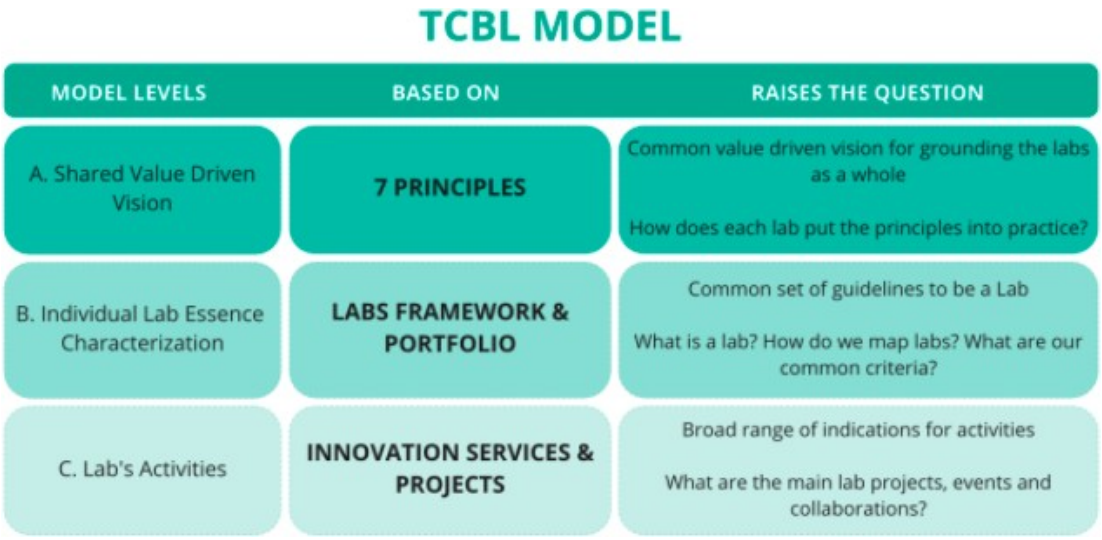

Figure 6: TCBL model (D3.1)

Fabricademy values	**TCBL principles**	**shemakes.eu values andintents**
Hybrid Learning: Combining online learning & Hands-On training by international experts. **Novel Careers Paths:** Working at the intersection of Digital Fabrication, Bio-design and Textiles. **Learning By Doing:** Expanding the practices of FabLabs with Textile Labs and Bio Labs **International Network:** Exchanging Knowledge With a community of like-minded individuals. **Open Source:** Promoting Open-Source Culture, sharing and collaborating.	**Curiosity:** Creative exploration of new paths, roles, social constructs and business models. **Viability:** Things should stand on their own feet, but can do so by equally increasing the prosperity of businesses and the well- being of communities; **Durability:** Commitment to the environment, towards circular economy and zero km. **Multiplicity:** Value of different cultures, traditions, opinions. Roles for both professionals and amateurs different labor specialisations. **Openness:** Trusting others by sharing resources and information. Respect and protection of privacy, authorship, and IP. Dignity of the individual, power of social knowledge	Approaching gender through **Collaboration.** Disrupting the textile industry through innovation. Empowering women in innovation ecosystems through **Inspiration, skill and networks.** Importance of "situated", "**distributed"...** Building new narratives and curriculum **for sustainable futures.** Value craft, spaces, creativity and territorial tradition, practices

Table 2: shemakes values and statement

Overview of the shemakes actors, values and activities

After the identification of the TCBL and Fabricademy actors, values and relationships individually, we mapped the situation and values related to the term innovation that influenced the project's development, identified the relationships of innovation, science and technology and identified references, advice and support from nearby projects on how to apply best practices to the shemakes.eu integrated ecosystem (mentioned in section 2.2 and Table 1.). Related initiatives and projects were also considered as guidance and values that we will further implement in the shemakes.eu activities (Figure 7).

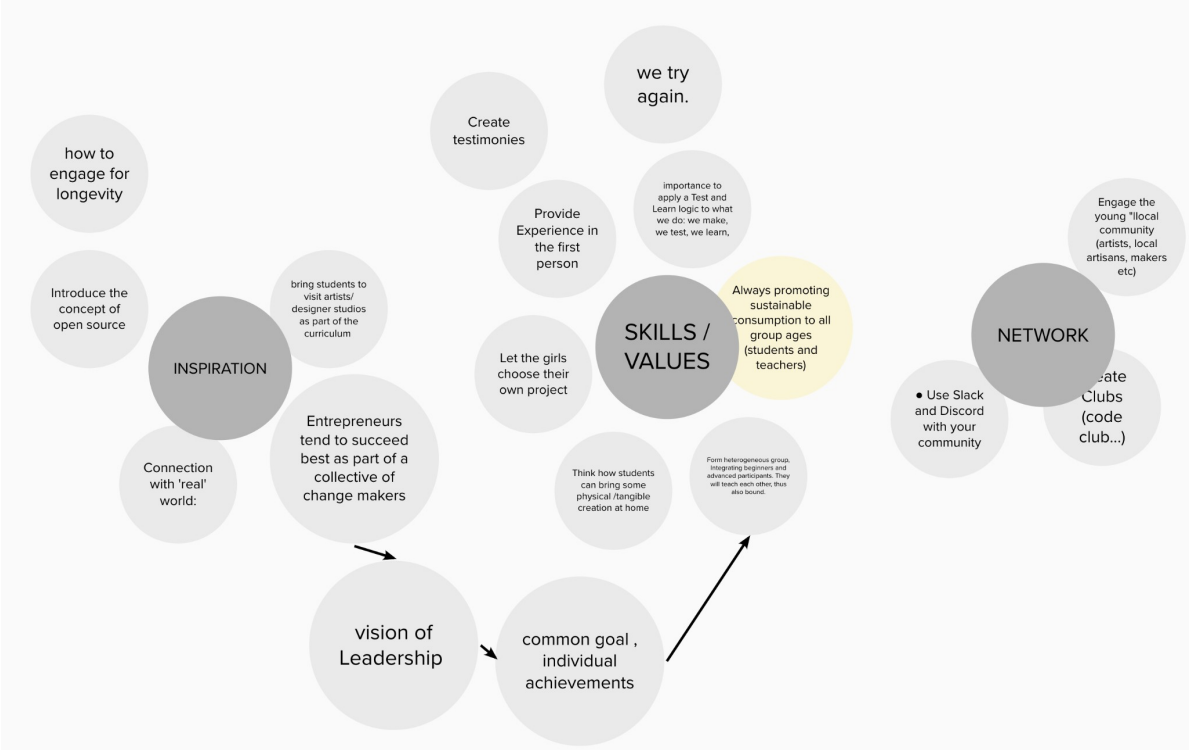

Figure 7: Overview of influences and values to foster in further practices of shemakes.eu

Since shemakes.eu aims at creating an inclusive, diverse and participatory ecosystem, the individual stakeholder perspective is especially relevant. Therefore, we focused in the closest sense through theco-creative processes, starting with listening to the women role models. In this case, the Advisory Board (prominent women in the field), who gave their first input, followed by the Gurus (leading mentor figures in the labs), identified their motivations and fears and roles as women, makers and entrepreneurs in their areas of expertise.

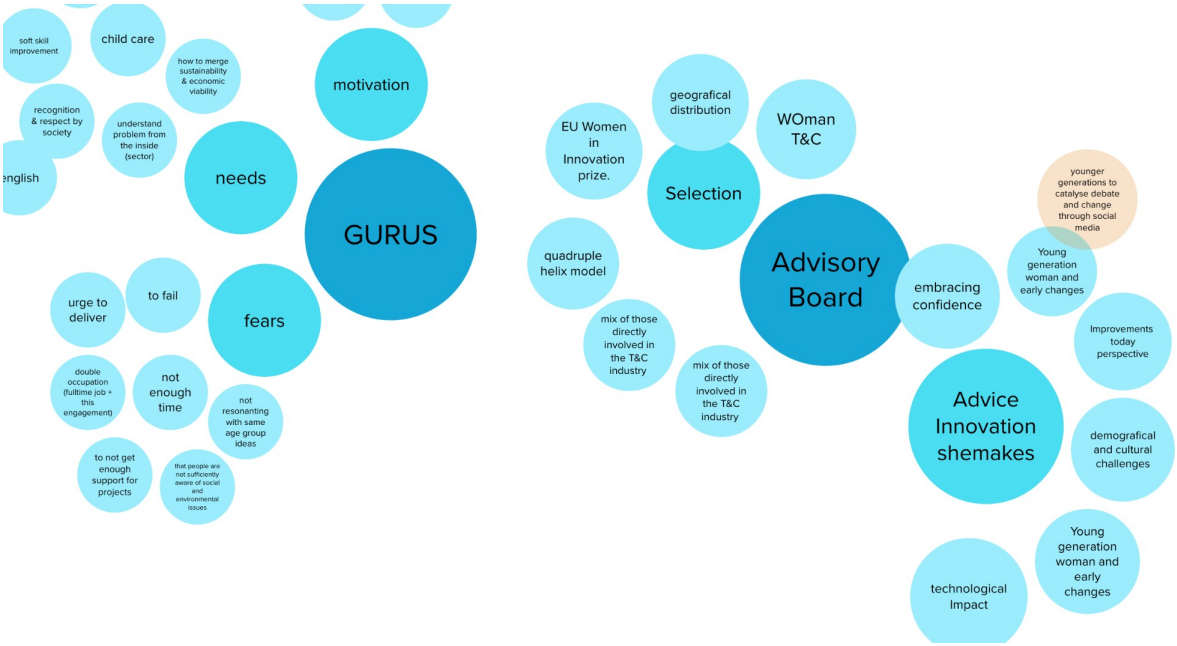

Figure 8: Overview of the innovation ecosystem mapping: Role Models

Then, the values and dynamics of the partner laboratories were identified, extracting their methods, values and relationships with existing actors. In the first months, the lab partners identified the relevant actors in the innovation helix framework, external interactions of the ecosystem, e.g. with institutional and scientific stakeholders, and interactions internal to the ecosystem. These would be strategic for the development of the project's activities. Due to the versatile spectrum of maker labs brought together in shemakes.eu (IAAC, Make Sense, WAAG, REDU, Onl'Fait, LEON) the ecosystem has astrong profile in education and training offers for women (Figure 9).

Figure 9: Overview of the innovation ecosystem mapping: Labs

The first outline of the shemakes.eu activities adopted the existing concepts of the Fabricademy research agenda (Figure 5). Further on, in the peer to peer Labs sessions and collaboration with participants of activities specially targeted at the innovation paths target group, women were questioned about possible obstacles in their innovation work. Here, the need to improve entrepreneurial and strategic skills and an interest in personal growth issues was formulated. Therefore, non-technical skills and education play a relevant role in developing the education and training ecosystem. These themes are represented within the Innovation Services area in Figure 10. Therefore, a crucial lever within the ecosystem is the dynamics between the different components and the external relationships.

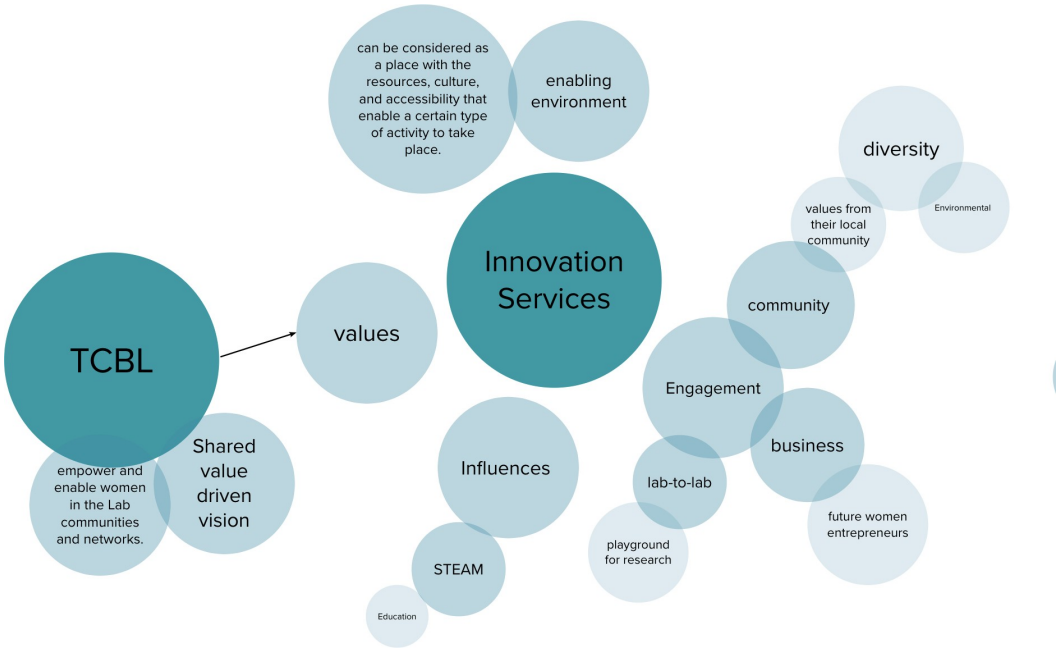

Figure 10: Overview of the innovation ecosystem mapping: Innovation services

The external perspective, e.g. interaction with government, research, the private sector, citizens and/or the environment, network activities, regulatory frameworks, community management and institutional support is mainly recognized by the project activities of reputation management and communication and dissemination, but they also play an important role across the project (i.e. in the case of regulatory aspects or stakeholder relations).

shemakes actors, values, and activities provide a foundation for future innovation interventions that will enable the system to become more efficient. The following phases of the project aim to ensure that this ecosystem can grow and become suitable for the emergence of new actors, activities, and engagement to strengthen it.[8]

3 Designing interventions to understand the gender gap and support bridging it

Following the third methodology co-creation session, design interventions were identified. These are introduced below, showing how some of these dynamics are applied to shemakes.eu's processes. Connecting the ecosystem already created, we present concrete activities carried out in the first months of the project. This process begins to define the tools we want to transfer to our audience, how to network them and how to identify leaders that can help the project's continuity.

The project foresees three forms of intervention to support functional and structural changes in the existing ecosystems, moving them towards more responsible practices in terms of gender by engaging

[8] the completed representation of the actors, values and activities can be found in the following link: https://app.mural.co/t/matrixgmbhcokg0728/m/matrixgmbhcokg0728/1620388253638/b4fb76e0bec9636cd452258a8f3d324c586d4cd7?sender=conferencing10443

more women of all ages, equipping them with more skills, and allowing them to access better working conditions, especially more equal salaries. The interventions are built on the existing practices and supported by co-creation tools and peer-learning exchanges among the stakeholders. The three types are as follows: the creation of learning paths, innovation services for labs and the promotion of women role models that echo the values of shemakes.eu.

Creating a series of learning activities to engage women from 8 to 108

Within shemakes.eu, we carry out a series of learning activities for girls and women in three differentage groups. We thus have three learning paths named “curiosity”, “discovery” and “innovation”. Each learning activity adapts the Fabricademy curricular topics to the specific age group while at all times engaging the girls and women participants. One of the key parts of these learning activities is to introduce them to new knowledge, helping them link subjects and enabling them to grow. That’s one aspect of how we engage women and girl participants, the other is with choices which explore their creativity.

For example, some of our learning activities combine craft and technology like E-textiles; this “expands the culture to include people with wider interests.“E-textiles offer an experience of doing technology that incorporates skills, perspectives, and interests that are traditionally part of the feminine realm” (Okerlund et al., 2018).

shemakes.eu thus creates and promotes activities such as E-textiles, building on existing projects such as Monster Dolls (Leon) and Voodoo dolls (On l’Fait)) to break stereotypes and cultural biases. This is an example of a learning activity for the “curiosity” learning path that engages labs to work with young girls.

Voodoo dolls/Voodoo Lapins was a workshop in collaboration with the Bibliothèque de la Cité. There were ten children aged 8 to 12 who transformed stuffed dolls into lovely voodoo electronic rabbits. This provided a unique introduction to sewing and electronics, with the ability to choose what the doll would look like.

Both activities combine two crafts that are stereotyped (sewing is associated with women and electronics is associated with men). These activities enable the participant to link both crafts by creating a doll. They also develop an introductory understanding of technological skills of electronics with handkill of sewing. Additionally, they promote the participants’ creativity by giving the choice of the aesthetics of the monster/voodoo dolls.

Innovation services in more inclusive lab environment

shemakes.eu also intervenes in the co-creation and innovation capacity of labs by analysing current organisational gaps and practices. To foment the engagement and bounding of the ecosystem, the innovation services work package organises a series of activities integrating a diversity of stakeholders. This offers the labs new opportunities to work on their sustainability and especially their strategies of inclusivity. It consists of running local community events, distributed lab-to-lab research and knowledge transfer projects and testing new programs to foster direct collaboration with businesses and to develop entrepreneurship skills especially for women.

General recommendations	
Absolute Dos	**Absolute Don'ts**
● Show commitment to gender equality, to equality of opportunity for participants (both women and men). The aim of gender approach is to establish genuine equal opportunities and promote diversity, in all its forms, throughout their lab/workshop participation, but also throughout all your Labs activities. ● Promote diversity in all forms of communication from the language to the interactions between participants. ● Be receptive to the multitude of opinions and points of view and communicate openly and gently with those around you. Embrace the facilitator role. ● Empower the roles of leader as an open and collaborative action, embracing the personality (each team member's role). ● Be respectful and mindful in your surroundings and to your fellow colleagues and participants also in the way you receive and give critique to ideas. ● Walk the talk, practice in your actions the values you preach. Mind the use of resources, care for recycling, zero waste approach, etc. ● Data privacy, make sure to have shared agreement on confidentiality / privacy ● Promote the free access and sharing of knowledge. through documentation and the facilitation of dialogue e.eg forum, open discussion that enables the growth of knowledge. ● Give the rights to the people who are making the intellectual, physical, and manufactured work.	● Don't partner with entities known for infringement with human rights and/or polluting companies. ● Don't accept any form of aggression, harassment, intimidation regardless of the mode of manifestation: verbal, physical or written. ● Don't accept any form of discrimination on the basis of gender, nationality, sexual orientation, race, age, disability, stereotyping. ● Avoid extreme attitudes that do not allow for open dialogue. ● Reject the negative language and misuse of the media in the publication of content
Future collective actions at the shemakes.eu ecosystem level ● Participate in the co-creation of a glossary for women makers ● Integrate activities and actions of shemakes.eu program at the local labs, either as transfer lab or associated Lab, interested in this initiative. Furthermore, it is crucial to give us feedback and contribute to the growth of the ecosystem. ● Join the shemakes.eu project in the way and commitment you would like to be engaged. Through the values "inspiration, skills and network" that we propose, adapt them in the framework proposed. ● Encourage participants to be aware of the diversity and framework we are proposing in shemakes.eu and be ambassadors or nodes to transfer knowledge and share experiences.	

Foster inclusivity and awaken your community at the lab and beyond the maker community level: ● Create an Inclusive Manifesto in your Lab aligned that reflects on the local and global values and actions about a diverse innovation ecosystem. ● Observe gender (un)-equalities and stereotypes, recognise them and skill and up-skill the behaviour to change dynamics. ● consider more participation of women e.g. makers, coders in a broader spectrum to embraces diversity and co-creation, ● Make sure that women are evenly represented in higher positions of your structure. ● "Train" your members about gendered innovation. ● Bring the gender perspective when designing and fabricating. Thus embrace an inclusive and diverse view when processes or products are developed.

Table 3: General recommendations for the maker movement

As an example, the labs partners decided to work on wool, transversally exploring the sector and its heritage, designing and making materials and tools based on circular and biodesign principles, digital fabrication and the search for more community empowerment and gender inclusivity.

Facilitating the development of women role models

The representation of leaders has a significant impact on innovation ecosystems. Therefore, role models are explored through the concept of reputation management, looking at the relationships and interactions between actors and the impact of these dynamics on the shemakes.eu ecosystem. This process is developed from different levels and experiences of innovation through gender, starting from the Ambassadors, who are participants of shemakes.eu activities bringing their experiences of local labs to new labs joining the network. The "Gurus" are expert leaders who articulate the knowledge from their labs throughout the project. Finally, the Advisory Board members give a global view and support the project to fulfil its mission for gender-driven innovation.

One of the exercises carried out developed persona maps to understand the personalities when faced with a leadership challenge for Gurus and Ambassadors. In this activity we ask about motivations, fears and future opportunities for learning, entrepreneurship and action in the gender gap as well as in the textile and fashion industry.

Through this analysis, it emerges that women's work is characterised by being collaborative and preserved over time, welcoming and empowering the positive characteristics of women's work, and promoting good practices. One of the lessons learned is that the role of women is to understand leadership as diversity and collaboration between networks of women. Through this approach, women, especially in the context of "women makers in the textile world", can become promoters of technological knowledge transfer and different values and competencies, enriching their opportunities for growth in the environments they choose to work in. In parallel, understanding women's shortcomings is also essential to building our innovation ecosystem.

4 Reflections and lessons learnt for the (Women) Maker Movement

Drawing on the experiences already made in the design interventions, in the following co-creation session we reflected among partners on tools and practices emerging in the shemakes model of labs and the three layers of intervention. These reflections were conceived to promote the sustainability of textile and clothing labs in and beyond the maker movement. This section extends these reflections to encourage best practices specifically in FabLab environments.

This process was carried out by gathering a series of tools and practices to act and reflect on the gender gap within the maker movement. Table 3 below presents some suggestions at three levels, individual,

labs, and beyond labs in shemakes.eu and towards gendered innovation.[9] These tips and lessons learnt are based on the first exploration realised within the project and feedback gathered from shemakes.eu partners, labs facilitators and participants in the various activities.

4.1 Conclusions

After exploring innovation ecosystems and the experiences of the ongoing action research in the EU-funded shemakes.eu project, we can already see evidence of a working innovative ecosystem for women makers to reduce the gender gap. shemakes.eu emphasises empowering future female innovators for a sustainable fashion industry through inspiration, skills and networks of different ages that enable the engagement of women and girls. The project is still ongoing and will thus further develop these findings and adapt its strategies through evaluation and reflection.

In this paper, we have presented the different aspects and dimensions of innovation in technological, scientific, and social innovation as well as in open innovation. We have described the factors that affect and make this environment optimal for the growth of the shemakes.eu innovation ecosystem. Furthermore, we identified the relationships between textiles and technology, the actors and gaps and how to take this into account to make the atmosphere more inclusive, especially as it regards themaker movement.

By investigating the link between women, technology and textiles, we show how, not surprisingly, women and the textile world are closely connected as this interplay is part of the social and cultural fabric of the history and constructs of industrial and political development. However, today's textile perspectives can offer an attractive and innovative environment for women innovators from the textile industry to different scientific and practical fields, such as STEAM, circular economy, industry 4.0, smart textiles, and entrepreneurship. Considering that the textile industry is one of the more polluting industries in the world, affecting climate change and its disastrous environmental consequences, there is a great opportunity for women to lead change by acting on the fashion system. As also highlighted in the input of the Advisory Board[10], *it seems that women are more activethan men in addressing the changes needed towards a more sustainable textile and fashion system*. Given the urgency of the situation, there is an important opportunity for women to take stronger leadership, even in less receptive contexts, from young generations to the “108”. As young generations are also consumers, the same as adults, they have the power to communicate responsible practices, follow and support collectives across borders and become positive role modelsfor society.

Labs are the spaces in which shemakes.eu has its core interactions. They are the environment where actors, communities, and activities work together. Our approach, as presented, builds on the principles of open innovation to promote an environment of social, scientific and institutional dimensions. This approach is built through knowledge generated individually and, in the community, the generation of local and global values, and the continuous feedback of knowledge that allows for the generation of more stable and lasting networks.

To tackle gender segregation and stereotypes, it is essential for society, particularly the Fab Community, to rethink their proposal for the main challenges for the future. Especially in recent years, digitalisation and ecological awareness have been a significant focus; we need to consider a “*care*” transition (Muñoz-Galvez, 2020) based on inclusivity and diversity awareness. Still, we need to promote and embrace a care and gender perspective and extrapolate this vision in closed environments. Implementing this approach for open ecosystems is a promising approach for all fab community initiatives[11], for innovation in the textile industry and beyond, in contributing to improve opportunities for women in innovation

[9] These recommendations are Introduced mainly from the deliverable “*Innovation Services Lunch*”, and completed to the purpose of the paper.

[10] Advisory Board interviews by the deliverable Reputation Lunch

[11] FabCity(*Fab City Global Initiative*,2021), Fabacademy(Fab Academy, 2018), Scope(*SCOPES Digital Fabrication – K-12 Digital Fabrication for STEM*, 2021) , Bioacademy(*Bio Academy - How to Grow (Almost) Anything*,2021) and Open Source Hardware (*Open Source Hardware Association* , 2021), among others

ecosystems. To do this, we need to work on how to engage girls and boys as active actors as well as adults and investors to foster an environment of equality and begin to change mindsets.

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