Art Tech Toolbox

Re-FREAM

Re-Thinking of Fashion in Research and Artist collaborating development for Urban Manufacturing

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S+T+ARTS LIGHTHOUSE RE-FREAM

PURPOSE

This booklet syntetizes the results of the desktop research phase of the Re-FREAM project WP2 - Art transfer Further information about the project can be found on the project website www.re-fream.eu

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STATEMENT OF ORIGINALITY

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Outline

Scientia sine arte nihil est. Ars sine scientia nihil est

Jean Vignot, French architect, 14th century.

Introduction

Alienus non diutius

Latin inscription at Pixar University

Photo by Zane Lee on Unsplash

This document is an output of the Re-FREAM project[1] , supported by the EU Horizon 2020 program.

Re-FREAM is exploring the interaction between the domains of Fashion, Design, Science, Craft and Technoogy, promoting a space for co-creation and research, where experimental projects will be connecting artists and professionals from the fashion with scientists and technologists.

As the fashion sector is constantly evolving and adapting, reflecting the mutable *zeitgeist* of a complex society, it is the art and the related design discipline that most effectively transmit the languages and messages of our contemporary culture. They have been amplifying their radar to reach all levels and industries such as home, lifestyle, and sports and finally: technology.

Nevertheless, fashion designers, brands and today's fashion education do not consciously include technology as a creative tool in their processes. Scientists, engineers and coders haven't direct access to the dynamic and enigmatic world of fashion.

Re-FREAM offers functioning as an incubator and accelerator of art-driven ideas, which are researching and demanding new processes, products, and services for the fashion sector. These experiments should overcome the limits of the sector itself and connecting the magic of fashion with new areas of expertise in technology, crafting and sciences.

The program intends to bridge passionate areas, creative but separated worlds, to make inspiring, intelligent and useful things happen.
In Re-FREAM it is needed to redefining the design process into an organic and flowing horizontal dialogue between different actors, where knowledge is shared and built upon. In order to generate new and unconventional knowledge, yielding mindful and creative solutions for our world, scientific structures should be redesigned into open spaces without limits, bringing together profiles from different areas to connect, experiment and create together. This Tech / Art Transfer Toolbox has been designed as a reference document, which could be of interest both for artists and sci/tech experts.

In Re-FREAM artists become researchers, mindful inventors. Scientists act as tutors who provide guidance and expertise.

Together the barriers of traditional creating and researching are blurred. Researching becomes a seamless process of exploring, collaborating, and experimenting through a constant and fearless search for the unknown, the undiscovered, the impossible.

It should be used by technology hub managers and facilitators as a possible source of inspiration for the implementation of an Art/Tech common playground, as well as a practical handbook for the selection of practical approaches.
For this purpose, the document is divided in three main sections.

The first is suggesting both general reflections on hybridization of arts and scientific research and evidencing the possible "revolutionary" role of arts in the sci/tech processes. We criticize the Cartesian dichotomy and envisage reconciliation among aesthetic and rationality, through a generative "conversation". The ideal playground is presented, taking inspiration from the "ba" space of the Japanese Zen philosophy. Knowledge should flow without barriers, shitching from tacit to explicit and from individuals to groups, independently from disciplines and hierarchies, as in the gold age of the Renaissance workshops.

The second section is reporting a set of tools, to be applied in the tech/art transfer process. Accelerated prototyping cycles, unlearning attitudes, as well as explicitation of work methods and co-design management would help in establishing and maintaining the appropriate playground.

Finally, in **the third** section, a selection of inspiring stories, interesting places and legacy projects will help the reader to find best practices and front-running approaches. We have selected representative experiences, spanning from the very acclaimed pioneers of techno-fahion, to less publicized, but significative game-changing experiences. We have also spotted on educational environments, where the dychotomy art-science is being overcome.

This Tech / Art Transfer Toolbox will be considered a "living document" and therefore it will be updated and integrated by the contribution of partners and the lessons learned along the Re-FREAM project.

The Toolbox will inform the design of the training activities and represent the background for drafting the extensive Co-Research Guidelines, due at the end of the project.

Why art and tech?

Photo by Lucas Vasuez on Unsplash

In a report from Tokyo in February 1990, the Italian journalist Tiziano Terzani wrote about the Japanese school: "At school, the child is not used to thinking with his own head, but trained to say the right thing at the right time.
For every question, there is an answer and that must be memorized. *'What happens when the snow melts?'* Asks the teacher, and the class, in a chorus, must answer *'Become water'*. If one comes to say: *'Spring is coming!' he is scolded"*.
In this episode, cited by the economist of innovation **Piero Formica** [1], we find represented the tremendous potential of the insertion of an "artistic" way of thinking into a consolidated cultural framework. The Sanskrit root of the Latin word ars is ăr_ that means "to go towards".

In a translated sense, the meaning is "to adapt", "to make", "to produce". In short, the artist is not distinguished by fatigue of the work, but by what he creates starting from an idea and a need to satisfy. This idea of progression from a "raw state" to an "upper state" is elsewhere embedded in the western languages: the Greek word αρ-ετή (ar-eté) means virtue, while the Germanic words related to work (ar-m, ar-beit), are descending from the ăr_ root, too.

There is no universally accepted definition of art.

Although commonly used to describe something of beauty, or a skill, which produces an aesthetic result, there is no clear line in principle between a unique piece of handmade sculpture and a mass-produced but visually attractive item. We might say that art requires thought - some kind of creative impulse - but this raises more questions: for example, how much thought is required? If someone flings paint at a canvas, hoping by this action to create a work of art, does the result automatically constitute art?
Even the notion of 'beauty' raises obvious questions.
Following the pop-art provocation, if someone thinks something is 'beautiful', or aesthetically pleasing, does that make it art? If not, does its status change if a million people happen to agree on that?

Another thing to be aware of is the fact that art reflects and belongs to the period and culture from which it is spawned. After all, how can we compare prehistoric murals or tribal art, or native Oceanic art, or primitive African art, with Michelangelo's frescoes in the Sistine Chapel? Political events are the most obvious factors that influence art: for example, art styles like Expressionism, Dada, and Surrealism were products of political uncertainty and upheavals.

Cultural differences, as well as religions, also act as natural borders. After all, Western draughtsmanship is light years away from Chinese calligraphy; and what Western artform compares with the art of origami paper folding from Japan?

For the purpose of this document, we will consider as art the fundamental attitude of any human to act on the surrounding reality in order to shape it. For us, art is essentially a "change-making" action. As stated by Joseph Beuys, it is a way to "mould and shape the world in which we live" [2].

This creative attitude has been dominating in the golden ages of any civilization when the role of the artists was central, and a seamless dialogue among them, scientist and entrepreneurial talents, was well established.

In the magic spots of the Italian Renaissance, for example, knowledge was at the center of value creation processes. The workshops of the artisans-artists were a melting-pot of artistic aims and scientific capacities: painters, sculptors, jewelers, writers met and collaborated with (either been also) architects, mathematicians, engineers, anatomists. Masaccio, Brunelleschi, Leonardo, Michelangelo, and many other polymaths were recombining, in an innovative framework, knowledge streaming from different disciplines. Aesthetic and poetic expressivity was then imbricated with scientific, social and economic values. It resulted in revolutionary ways of working and living, a path to prosperity, which would have again characterized, after some decades, the golden ages in Netherland and Great Britain.

This triggering role is at the core of contemporary successful companies as Apple and Pixar. Ed Catmull, Pixar's President, explained in an interview that

> *"creative people need to drive the innovation, not the technical people or management. Given this high level of trust, the creative workforce works hard to include everyone else in their decision-making, and deliver a high-quality product."*[2]

This toolbox has the aim to suggest a methodology to restart the dialogue, bringing the artists at the very core of the generation of scientific and technical knowledge. Promoting transculturation is our goal: we wish art, science, and technology interacting in a network of mutual exchange of cultural influences that overlap each other.

Overcoming a bureaucratic approach, resulting from the well-established industrial research pipeline, we would promote co-creation processes, where small and transdisciplinary teams are moving from the agreement of a common playground, along with the steps of the innovation path.

Consumers of today and tomorrow are going to choose for themselves, creating and designing their own wardrobes

Lidewij Edelkoort, Anti_Fashion manifesto

Is this toolkit for you?

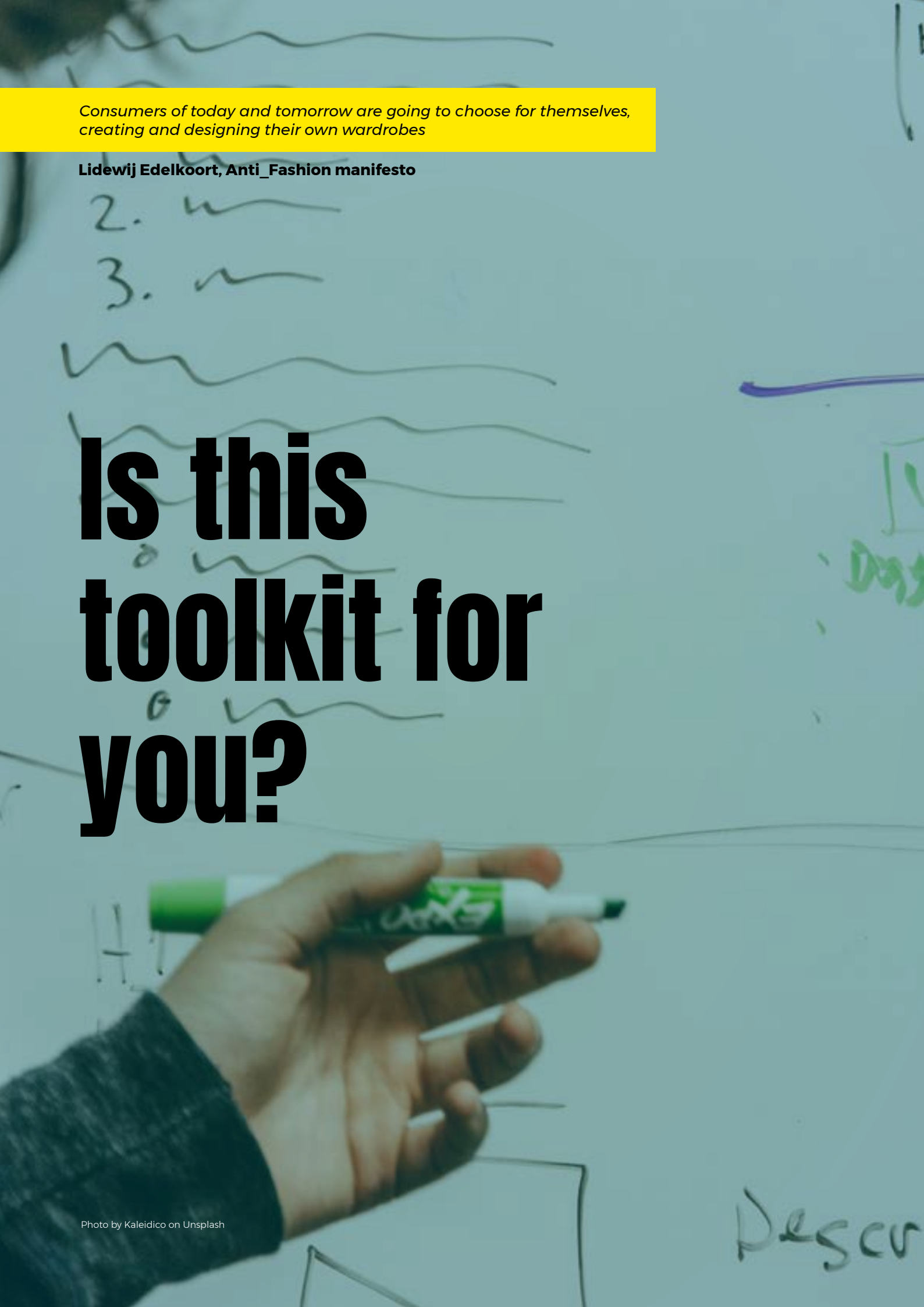


Photo by Kaleidico on Unsplash

A revolution is envisaged in the fashion industry. Li Edelkoort, in her Anti_Fashion Manifesto[3] represents the obsolescence of the fashion industry and launches a call for the renaissance of clothing.

A new era that needs new ways of thinking, new ideas, new alliances, a radical transformation of consolidated processes.

As an artist, designer, creative, as well as a technologist or scientist, you should be motivated to be part of such revolution and reflect on the way to establish a new common playground.
This guide wishes to bring under the practictioners' attention, both conceptual and practical issues and methods for changing the relationship between artists and technologists, as we believe they could be – together – the engine of change.
Experimental fashion is already operating as a bridge between design and different disciplines, such as neuroscience or biology that, in a not so distant past, were considered not to be associated with fashion at all. Pioneering artists and designers are working together with technologists, scientist, neuroscientists, biologists, and multimedia and software engineers to create a new set of skills and methodologies [3] [4] [5] [6].
Accordingly with the design scholar Marinella Ferrara: *"the cross-disciplinarily promises innovation that shifts focus beyond the traditional use of dresses to embrace uncertainty, interpretation, and new meanings"* [7].
Therefore, you may be interested in exploring new aesthetics, to search the 'magic' of smart garments, in terms of "wow effect" or "superpower", either to democratize the access to technologies or to drive fashion design towards sustainability.

Regardless of your present status, you are invited to read the content, experience the process and access to the broad list of references and case studies with a thorough understanding of the other actors and the opportunities arising from the dialogue. We are confident that this will empower you to create solutions on an entirely different plane by embracing on experimentations, coupled with prototyping and feedback, and allowing you to fail and break out of the box.

The suggested methodology states an iterative cycle, which starts from establishing an empathic mindset among real people with real challenges in real spaces, enabling new and unconventional creative paths towards art and technology inspired interventions.

As you will go through the suggested reflections and recommended activities you will realize that your context is people and place-specific and may slightly differ in any reported example. That's good: you found models to understand and modify. Remember that this toolkit is available to help you think, test, fail early and often.

Please, approach our suggestions with the right mindset, embrace the ambiguity of the topic and learn from success and especially failure.

Art in the research of “possible”

Photo by Drew Hays on Unsplash

If you don't know where you're going, how do you know when you get there?

The assumption is that clearly defined intentions, whether expressed as hypotheses, research questions, lesson objectives, or standard statements, position the purpose of research actions within the context of what is already known. Consequently, outcomes can be readily assessed according to the conceptual limits imposed, as this gives a measure of utility in comparing the new with the old. Knowledge in this sense is expressed as a difference in "degree" or quantity and is compared to other things we already know.

This is how we construct theories of "probable".

However, as many in the arts and the sciences have argued, the formal specification of intended outcomes does not necessarily mean that valuable, unintended consequences are not possible - one just has to be open to possibility and curiosity. With this in mind, we could assert that *if you don't know where you're going, then it is best to surround a problem in order to solve it.* With this approach, knowledge emerges from an analytic and holistic account through consensus and corroboration where patterns and themes are the elements used to represent complex realities.

This is how we can construct theories of "plausible".

But, how do we construct theories of "possible"?

An arts researcher would more than likely subscribe to the view that if you don't know where you are going, then any road will get you there. Rather than seeing inquiry as a linear procedure or an enclosing process, research acts can also be interactive and reflexive, whereby imaginative insight is constructed from a creative and critical practice. Often, what is known can limit the possibility of what is not and this requires a creative act to see things from a new view.
An inquiry process involving interpretive and critical acts is then possible as new insights confirm, challenge or change our understanding. If an agreed goal of the research is the creation of new knowledge, then it should be agreed that this can be achieved by following different, yet complementary pathways. What is common is the attention given to the systematic and rigorous inquiry, yet in a way that emphasizes what is "*possible*", to "*create and critique*" together.

This can be the foundational act of the common journey between artists and scientists [8].

Limit and openness:

towards art-based research

Photo by Bonneval Sebastien on Unsplash

In our view, arts-based research integrates artistic activities within a sci-tech research process, and/or vice-versa.

For some authors, it means that the researcher uses her/his own artistic expression as a means of inquiry, i.e. close to the sense of "*artistic knowing*". For others, it also includes art-based action research, i.e. the use of art in action-oriented research that aims at "change through art" [9] [10] [11] [12]. Art-based research can be defined as the systematic use of the artistic process, the actual making of artistic expressions in all of the different forms of the arts, as a primary way of understanding and examining experience by both researchers and the people that they involve in their studies. In this approach "change-making" is the core dimension.
We can again refer to Joseph Beuys for his definition of the Art–Science, which is, accordingly to Wildgen:

> *"not a pathway towards a scientific model in the strict sense"* but represent an effort to promote innovative science through *"theoretical intuitions, which can be sketched diagrammatically and later lead to exact theories if a proper mathematical formulation is found and if the predictions of such a model are checked in experiments or evaluated in relation to given observations"*.

In such a way, Beuys' iteration and integration between art and science had the aim to promote a transdisciplinary approach to face the most urgent social and environmental challenges [2].

These inquiries are quite different from research activities where the arts may play a significant role but are essentially used as data for investigations that take place within academic disciplines that utilize more traditional scientific, verbal, and mathematical descriptions and analyses of phenomena. In a society that is increasingly conditioned by structural transformation processes induced by science and technology, we are urged to reconsider the central role of art in the generation, development, presentation, and dissemination of knowledge.
As in the Renaissance workshops, this intersection between art, science, and technology is generative of new artistic paradigms, new perspectives for economic wealth and a new solution for the formidable challenges raised from the current economic and social model.

Nowadays, the art-based research can be seen as a complex process affected by the convergent and divergent attitudes of artistic creativity with respect to the scientific method, but also by the implications of the unknown outcome of its performative and pragmatic repercussion.

How can we identify the activity of the artist who intervenes outside his own field of that of other social actors?

How can we delimit the field of action of each of the agents involved in the process to create an efficient and effective collaboration environment?

When the artist couples his activity, for example, to scientific objectives such as obtaining verifiable scientific results, to what extent can his activity be differentiated from that of a scientist?

Is interdisciplinary art dissolved in other areas of knowledge or can it be constituted as a new aspect of art?

The analysis of the historical and current links between art, science, and technology lead us to verify a double need: to demarcate a limit or the autonomy of each discipline and to establish opening dynamics that, in this oscillating sense, we call the binomial "limit/opening" between different approaches to knowledge.
This oscillation between limit and openness is evidenced by the shift from interdisciplinary openness tendencies, which characterized the sixties, to the "wars of the sciences" of the nineties of the last century. Numerous questions arise from the study of such boundaries.

How are the objects of scientific study different from artistic ones?

Can we speak of a scientific methodological determination in artistic practices or of an artistic incidence in the scientific method?

On the other hand, can science rely on the efficiency of art to establish these research channels achieving efficient results?

Can we methodically introduce, through art, the unforeseen, the unexpected, into a scientific investigation?

The question of the social impact of new artistic performativity that comes from the will to act in other fields generates the need to redefine the epistemological components of art and rethink its social functions.

To this end, we will consider the "will to know", in the Foucault perspective, as the common driver to generate useful knowledge, the common playground where art and science can merge.
Of course, this approach is deeply challenging the power structures of the dominant fields of knowledge and established technologies, as the artistic *"blind spot"* is explicitly called to play a role in the process of demanding and generating new knowledge of scientific relevance.

Clothes are semiotic devices, machines for communication

Umberto Eco

Bridging the gap

Photos by Floriana Benigno

Introducing this toolkit about the convergence of art and science, we have already alluded to the perspective represented by Renaissance art, which turned its gaze to antiquity and was oriented by its notion of the *"truth of nature"*. Thus, for example, its concepts of harmony and architectural beauty were founded from the formative proportions of nature and, because of that, art had to be governed by the application of scientific knowledge.

The artist shouldn't imitate Nature but reflect its principles and laws.
In short, the Renaissance perspective gives art a position of science.

One of the reasons why the paths of art and science bifurcated later is that the concept of Cartesian rational knowledge, which involves the separation of the body and the mind. That means dissociating our perception of the world in a rational relationship and in another sensitive-emotional one. The theory of art cannot establish a separation between the senses and meaning since it follows a process of creation and imagination of meaning closely linked to matter and sensitive appearance, so that its conception is opposed to Cartesian rationality. When the skepticism of Descartes in front of the human senses, defined mathematical thought as the only methodical defender in the production of accurate knowledge, a countermovement was created, in turn skeptical, in relation to scientific knowledge.The appearance of the autonomous discipline of aesthetics was its direct consequence: the aesthetic skepticism in front of scientific rationality generated the idea of the aesthetic judgment of Kant, who outlined a divergent development between art and science.

The history of the epistemological tradition in aesthetics appears here as a history of the bifurcation of knowledge:

sensible knowledge
versus
cognitive knowledge

knowledge of appearance
versus
mathematical knowledge

aesthetic judgment
versus
knowledge judgment

Aesthetics becomes an alternative to science and the artists can be reduced to practitioners of the ability to generate emotions instead of knowledge. Nowadays, a new cycle seems to arise from the systemic difficulty of the rationalistic approach to solve problems that our complex societies are generating.

While science does not usually confront its paradigm with methodological and theoretical alternatives, experimentation proliferates in times of crisis. According to Kuhn, it is only in a period of crisis between "normal science" and "revolutionary science" that multiplication of alternative methods takes place, since the "normal science" that determines, most of the time, the modes of regulated working has no interest in changing the established tools.

In this sense, we can take into account the possibility that both science and art can be transformed as a result of common and plural debate.

Where will the artistic-scientific research lines be developed?

What future role can art play in the introduction of new objects of study in science?

So we return to the main concern of this section of the guide: what are the conditions under which the objects of study are shared between the domains of science and art?

Could those ones be merged again into an hybrid domain?

To be able to address this question, we need to discuss also the influence of technological transformations on art.

Technology is commonly associated with an *"inhuman"* vision, which is accompanied by an ideological resistance of a part of the society to its practical application and integration. The artist may feel the risk of the loss of the signature, that is, the devaluation of *"the hand of the artist"*.

But, despite this ideological resistance to the mechanicistic aesthetic, art did not cease to reflect the discursive practices that entail the multiple technological inventions of the 20th century. Proof of this is the "techno-art" from futurism, constructivism, and Bauhaus to kinetic art, avant-garde cinema, video-art, and computer-generated art. It is a crucial and relevant example for this guide, the moment in which the Bauhaus, influenced by the suprematist approach to technology, fused the Faculty of Fine Arts and the School of Applied Arts in the same institution.

In it, artists and craftsmen came together to become inventors of new forms adapted to their social function. Manual work gets based on industrial technique, and while manual work and artistic beauty serve as a model for industrial production, art becomes governed by technical models and criteria of functionality, usefulness and material adequacy.

When objects are defined by their function, new conditions of the production of knowledge are arising, by the multiplication of the possible experimental and theoretical systems through the expanded heuristic capacity of art.

While the model specifies a new problem and the possibilities of an innovative resolution of it, the method determines the rules of procedure of the investigation.
The new "collaboration models" that emerge from the dialogue among art science and technology require a translation and heuristic effort, with specific contributions from each knowledge area / functional system and the predisposition to admit oscillating / contingent conceptualizations and visualizations while including:

- **a plural participation by a non-specialized audience**
- **bidirectional and non-local relations**
- **social mediated interactions**

since the new process ideally creates non-hierarchical relationships between experts and non-experts as well as experts from different disciplines.

On the other hand, in these trans-epistemic collaborations, the objects of study and the methods to investigate them are generated in the same research process and, therefore, may differ from the order of knowledge and the procedures established by the single disciplines.
Therefore, it is necessary to think about new possibilities to facilitate the collaboration processes, establishing co-creation as a research language.

In the Renaissance, scientific knowledge was used to introduce harmony and beauty in art.

Can we now use art to move further the scientific knowledge?

Can the co-creation process give science and technology the quality of art?

We can also recognize that, in our specific field of interest, science and technology are challenging the epistemology of normal fashion design.

Is this opening the path for a revolutionary fashion age?

And which kind of revolution?

Neri Oxman at the MIT Media Lab is exploring such possibilities:

> *"instead of arriving at beauty through function, or usefulness, we take the opposite route: arriving at new functionalities through an almost obsessive preoccupation with material properties and effects. This approach is at the very core of my work and group. We do not solve problems; we invent new technologies that offer new ways by which to engage with the world around us. If we are lucky, we get to discover solutions to problems we may not have known existed".*[4]

Finally, she adds the ethical dimension, as the responsibility that comes with freedom of exploration and expression in the boundary between art and science. She calls it ***"formalism with a moral compass"*** as the commitment to questioning the impact of such new technologies while ***"taking joy in the unknown and the ambiguous, the state of becoming"***.

Therefore, "bridging the gap", seems of paramount importance for a revolution of the fashion industry, both in aesthetic and ethic therms. From the artist-scientist dialogue, we expect to disclose hidden challenges and see unforeseen solutions to emerge.

For this dialogue to be carried on, we suggest to define a co-creation playspace.

The co-creation playspace

Photo by Floriana Benigno

Traditional design projects typically see a paying client on one side, and professionals within similar and related industries, on the other side. In co-creation, members of the design team are equally legitimate stakeholders with the ability to impact the project. The very literal meaning of co-creation is: together (co-) make or produce something (new) to exist (creation).

It finds its origin in co-production where consumer participation was integrated into the supply chain. Co-creation methodology is part of a vision that prefers cross-cultural and interdisciplinary teamwork as a contemporary response to the reading of the complexity and the production of meaningful innovation [13] [14] [15] [16]. It operates in and for the culture of cooperation, it is a groupal act inside the individual which implies that every creation has a plural-creator. Co-creation is a process of awakening: reality is a shared point of view, creativity is energy available to every individual, and creative-acts contribute to personal and collective growth. Co-creation can drive a sustainable change when resources, limits and potential are connected and in equilibrium.

For this reasons, team, location, time and structure are the critical elements that support the development of the process.

- **Team:** it is important to establish a stable transdisciplinary co-creation team, whose members compromise their efforts during the whole the Art/Tech Research Process. This method should be supported in changes and expansions as team modifications affect and impact the co-creation process.
- **Location:** a place designed for all the multidisciplinary technologies that will be needed to approach the idea.
- **Time:** it is important to schedule once the project starts to establish the checkpoints needs goals that the team need to accomplish during that process.
- **Structure:** the methodology won't be a process but a full module structure that may vary from one research to another. It will work as a puzzle that considers the humans AND the artifact needs at the same time.

Phase 1 -> ENVISION

The co-creation dialogue should be a *"conversation"*, literally a joint dancing (from the Latin *cum versare*), a fashinating metaphor introduced by Ferdinando Galiani, a Neapolitan economist of the 18th century to represent the development of marketplaces.
This "dance" needs a well-designed place (and process), where common languages can be emphatically established, shared goals are emerging throughout the path, hypothesis and solutions are iteratively explored, verified and eventually discarded. The function of this playspaces reminds again of the Renaissance workshop model, where dreams, passions, and projects could intertwine, out of the medieval scholastic environments. In these innovation hot-spots, artists and scientists/ technologists, as well as students, workers, and artisans should be free of interact, interdependent yet independent, under a loose level of coordination.

As Piero Formica says:

"what can those who want to create more innovative and collaborative workplaces today — whether that's a better office in a traditional organization, a coworking space, a startup incubator, or a fablab — learn from the workshops of the Renaissance? The bottegas' three major selling points were turning ideas into action, fostering dialogue, and facilitating the convergence of art and science" [1].

According to that, the playspace should be arranged in a way that supports the immediate action, making ideas become reality. This is challenging both the arts and science worlds, which are very well organized to make "their" ideas become reality, in their specific spaces, not the ones arising from a co-creation process.
It is suggested to start designing the art-tech playspaces as "buffer zones" connected with the research labs, where co-creation activities can be easily implemented and the combined intelligence of people with different skills and abilities would flourish. In this spaces the coexistence, but also the constructive collision of diverse talents, from the arts and the science/tech domains, should be continuously facilitated, removing cognitive constraints and deadlocks, but letting opposing ideas and controversial opinions to be represented and discussed.
Only in these "imperfect" environments, intuition will flow through imagination and, thereafter, creativity: questions will exceed answers, conversation happens, exploration develops out from highly formalized procedures that stifle the sources of intuition and imagination.
Therefore, these places should look like "experimental rooms" - quite different from "expert rooms", which are familiar to traditional innovators who live in the established wells of their specific knowledge.

Phase 2 -> EMPHATIZE

Experts are asked to enter in the experimental playspace with light luggage, that is, not burdened by accumulated knowledge. At the same time, the artists will be asked to raise their sensibility towards week signals, and to expand their understanding of cultural barriers.
They should be both led by the facilitators of the playspace, to socialize and pursue together to experiment with new ways of proceeding. Individuals should be smoothly brought outside their "knowledge wells", recognizing them for their propensity to behave as "ignorant creatives", and no longer by the name of their discipline, as to trigger teamwork driven by the "wild" ignorance, instead of the "wise" experience.
The benefit of the crossover among disciplines should be part of the cultural framework. In particular, the inversion between thesis and hypothesis, which could arise from arts, could have a formidable role in boosting innovative scientific ideas.
That already happened many times in the history of civilization, when science has been asked to formulate theories in front of challenges and solutions arising from intuition, imagination, and practical actions.

As **Edward de Bono** is suggesting in one of his famour quotes, a "constructionist" spirit should be adopted: *"ago ergo erigo"* should prevail on the deductionist *"**cogito ergo sum**"*. In an action-driven open innovation environment, the technical rationality and the imaginative anticipation would recover their pre-cartesian unity.

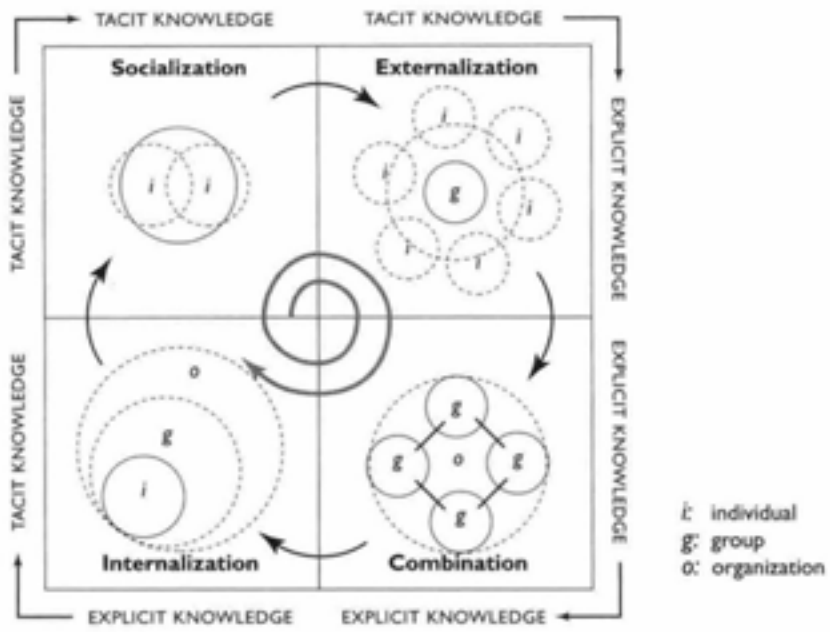
According to Simon Nicholson`s *"theory of loose parts"*, human interaction is usually affected by laces or activities, which are "clean, static and impossible to play around with". In this sense, they're missing of "loose parts" [15].
Those are free variables, which go beyond physical materials to include phenomena and mental activities. In planning the playspace, it is warmly recommended to establish the needed "loose parts". A place and people-specific approach are suggested, starting from real-life stories, experiences, and issues of individuals. The availability of materials and infrastructures that allows people to invent, construct, evaluate, or remix their own background, would be of great help.
During this phase, all the members of the co-creation project should be engaged in building an emphatic mood, through sessions of sharing, listening and making simple but significant things together.
The main goal is to build up a team formed by all the multidisciplinary parties able to detect the strengths of all the team members on a willing of taking the best of each member and coming all together in a midpoint. The startup phase is the critical one: once ignited, the co-creation process would never stop.

Phase 3 -> EXPERIENCE

> *"Experiencing means knowing things as they are. It means knowing them by completely putting aside their artifices and being guided by the things themselves. Since, usually, when one speaks of experience one also understands a certain mental activity, here one can indicate with "pure" the condition of experience as it really is, without the addition of even the slightest thought or even the slightest reflection. For example, when we see a color or hear a sound, the pure experience is that of the previous moment not only of the addition of our judgment about the external provenance of what we see or hear or any sensation we experience but is even earlier to the identification of color or sound. Pure experience is therefore synonymous with direct experience. When one experiences one's conscious state, there is no subject or object; the knowledge and the object of knowledge are the exact same thing. This is the purest form of experience".*

This attitude, proposed by the Japanese philosopher **Kitaro Nishida** as part of the Zen search for the Good, is what we would establish in the art-tech playspace [16]. Therefore, it should be the world of *"**ba**"*, which is the Nishida's philosophy the "place", a protected "harbor" where emerging relationships can be established. This space can be physical, virtual, mental or any combination of them. *"Ba"* provides an effective platform for advancing individual and/or collective knowledge. The "ba" approach was adopted by Ikujiro Nonaka for the purpose of elaborating a comprehensive model of knowledge creation, named **SECI** [17].

The SECI model tackles the issue, with four steps that flourish in spiral iteration between the individual and the group, and betweek tacit and explicit knowledge. As a matter of fact, it describes a co-creation process, where each person has the ability to create and innovate, being the enzyme of transformation that needs to be reorganized within the dynamics of a group in action in a shared design environment.



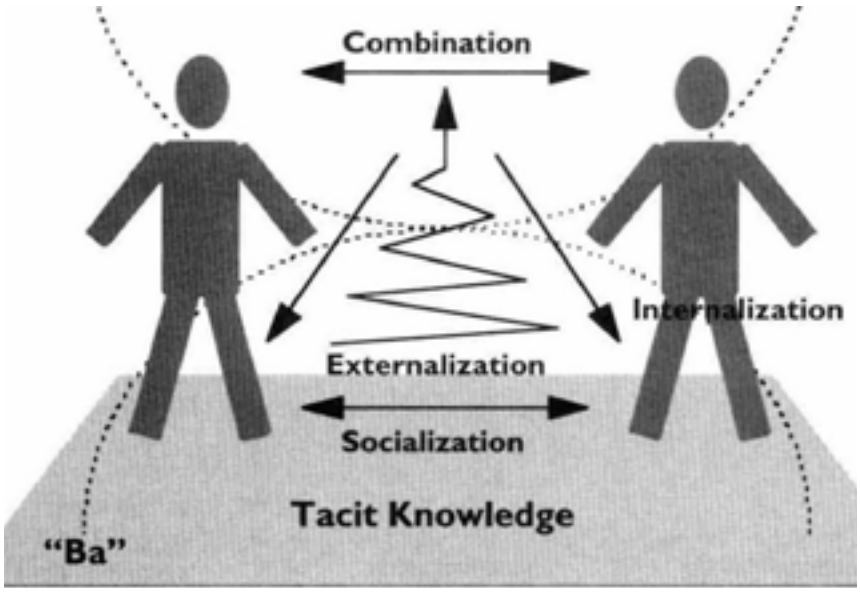
Spiral evolution of knowledge conversion and self-trascending process, accordingly to the SECI model by Ikujiro Nonaka.

The figure, we adapted from Nonaka, shows the continuous flow of knowledge that established in the model.

A number of activities, as informal and formal meetings, lab sessions, and free time conversation should be promoted in order to activate the flow between tacit and explicit knowledge and between individuals and groups/organizations.

The **socialization phase**, is made possible by the emphatic playground, with its "loose parts", which enables the conversion of tacit knowledge through interaction between individuals. It is worth to say that, at this stage, tacit knowledge can be transferred without language, but by observation, imitation and practice. Bring artists into sci/tech hubs, make them socialize and interact, give time to observation and imitation to become experience. Without this form of shared experience, it is extremely difficult for people to share each other' thinking process.

Ba and knowledge evolution in the SECI model.



During the externalization phase, tacit knowledge, which is available both the art and sci/tech side should be translated into comprehensible forms that can be understood by others.

In philosophical terms, the individual must transcend the inner and outer boundaries of the self. This can be achieved by presentations, forums, dialogues, cross-media artifacts, either other creative ways of representing ideas. At this stage, the individual commits to the group and thus becomes one with the group. Finally, individuals' intentions and ideas become integrated with the group's mental world and the tacit knowledge of people is translated into readily understandable forms.
This may require deductive/inductive reasoning or creative inference.

The internalization phase of the newly created knowledge will result in the conversion of explicit knowledge into the organization's tacit knowledge at the art-tech hub level.

Other individuals, at the hub hosting organization, will have access to the externalized knowledge through learning by doing, training and other exercises. In this sense, the explicit knowledge, developed at the group level, is again embodied in action and practice, actualizing concepts or methods about strategy, tactics, innovation and improvement.

Combination phase involves the conversion of explicit knowledge into more complex sets of explicit knowledge.

Systemization, communication and diffusion processes will support a new externalization stage, which will transcend the hub hosting organization. At this stage, data analysis, benchmarking, and other explicit knowledge processing activities are envisaged. These may result in **justification**, i.e. in agreements about the embodiment of the art-tech process in the organization and **conversion**, i.e. in cultural and social processes of recombination, recategorization and recontextualization of explicit knowledge, which was already available at the hub, into new knowledge, cross-cutting the art and sci-tech domains.

The whole experiential process is then characterized by the openness to serendipitous occurrences, and, at the same time by an attitude to catch the unexpected knowledge from the tacit level and bring it to an explicit level of individual and organizational embodiment.
The knowledge creation process can be also re-mapped in terms of phases of group work and of new product development.

By the introduction of dialogue exercises, practical phases, structured debriefings, outcome validation, it could be designed in four macro-phases of groupwork:

1. **analysis** (observation)
2. **concept generation** (co-generation)
3. **restitution** (action)
4. **metabolization of the innovation** (integration)

In the following scheme, proposed by ***artway of thinking***[5], the co-creation cycle is represented in terms of individual experience.

The co-creation cycle proposed by artway of thinking is built around the individual experience.

If we review the co-creation process in terms of new product development, it presents a beginning and an ending, and in the middle, a series of iterative steps that the teams might adapt to their needs and types of intelligence at work:

1. **Ideation:** During that phase, the idea is presented, visited, revisited, questioned, modified and at the end, redefined. The proposal will come from the artist, who should have access to the right ambiance to present the project, while the scientists should have the time to understand the proposal as a whole and its parts, which could be difficult to understand, as they are art driven and do not arise through a logical scientific process.

2. **Research:** During this phase, tools and knowledge needed for a deep understanding of the idea and its implications are inquiried.

3. **Prototyping**: During this phase, all the elements and models of the artifact being developed are produced on a proto-state for testing their main objectives.

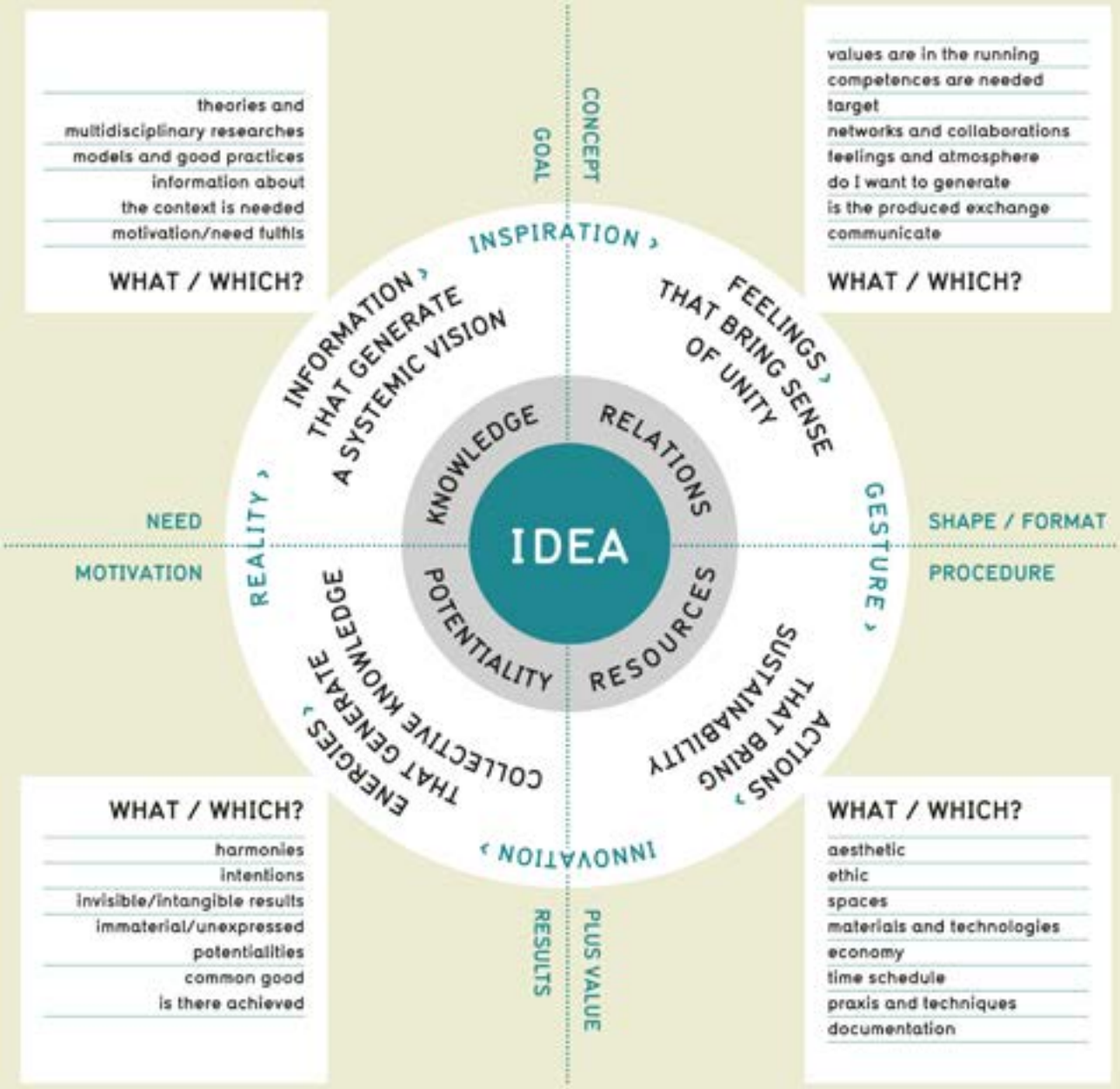
4. **Testing:** Here the different solutions are put under examination and validated on the prototype.

5. **Checking:** At this stage it must be decided whether the artifact is ready to be produced or should go through another iteration round to improve it.

The following scheme, again from artway of thinking, represents the knowledge ecosystem, which is needed around an idea to be developed in a co-creation framework.

The knowledge ecosystem to be established along the process of development of an idea in a co-creation framework, as suggested by artway of thinking.

CO-CREATION PROCESS CHART



artway of thinking

Inspiring Tools

Photo by Floriana Benigno

In the art-tech playspace, the use of explorative, non-linear, open innovation tools is suggested. Here we report a brief description of some inspiring approaches that might be case-by-case introduced by the art-tech facilitator in order to establish and maintain a generative process.

Unlearning

Following the teaching of **Patrick Kim Cheng Low**, whe should be able to unlearn, in order to become able to learn again [18].
He refers to unlearning as the process to dismantling and breaking down or away from the old ways of discovering knowledge: (re)learning will take place after the dismantling. He describes the unlearning and learning as the Yin and Yang of learning:

> *The Yin must occur before the Yang can take place. There should be a marriage or a unity of the opposites (Yin-Yang/unlearning-learning) for effective learning to take place. [...] When the cup is full, it will overflow. In order to pour, say water, into the cup, the contents reduced or unfilled or may need to be emptied. To use an analogy, just as an empty cup is useful, the usefulness lies in the emptiness of one's mind, so also when there is unlearning (the brain is 'unfilled' or more specifically, the mind is clear), the human mind learns. By the same token, we need to unlearn in order to learn or relearn.*

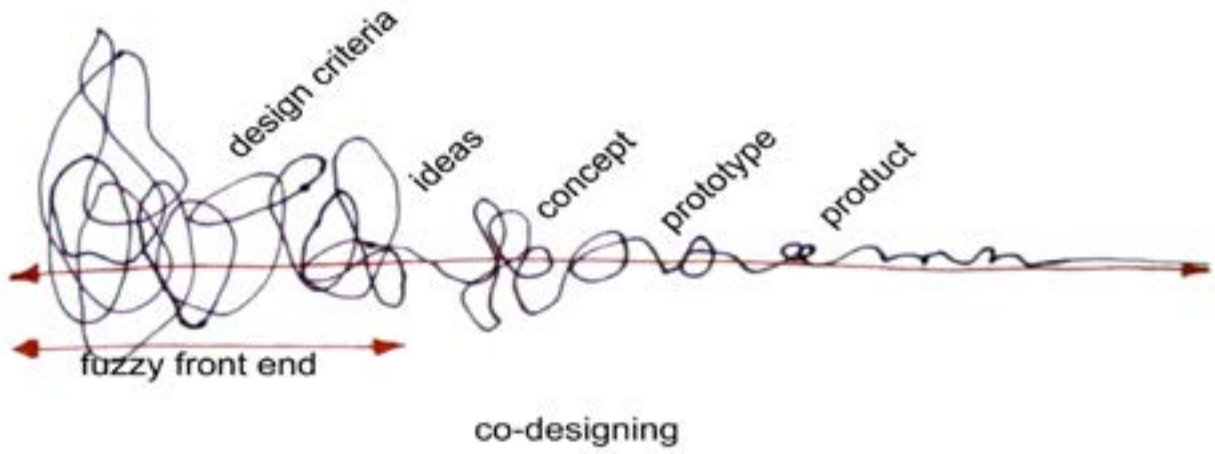
As the risk of "group-thinking" polarization is very high in the art-tech process, we suggest adopting the unlearning approach, along with the facilitation activities. The basic steps, accordingly to Cheng Low are illustrated below.

Acquisition of new knowledge by reviewing existing knowledge and unlearning.

An unlearning process should be implemented in the tech hub, supporting the host artists to fill the "empty" spaces, which are generated by the process, with new questions and challenges. This should help in unlocking "trapped minds", removing and group-think deadlocks and promoting "detachment" from the business-as-usual approach and scheduling [19].

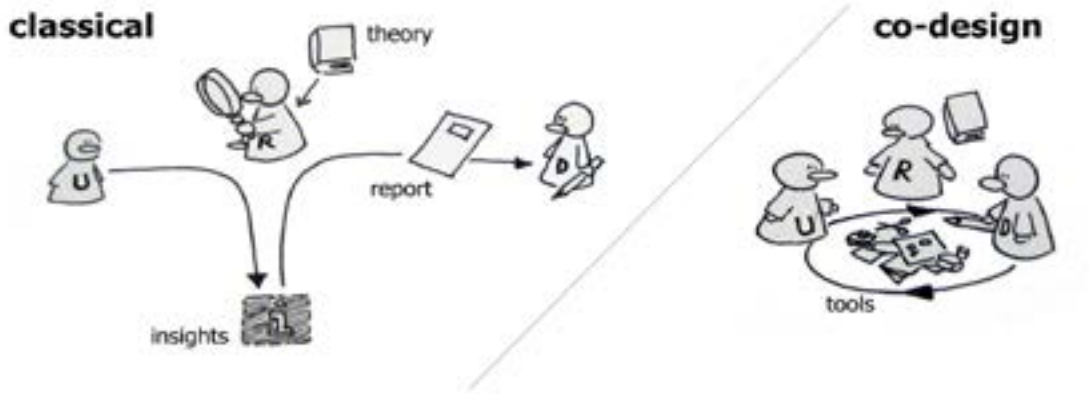
Co-Design radar

Elizabeth Sanders and **Pieter Jan Stappers** suggest a description of the co-design research process from the fuzzy front-end to the final release [20].



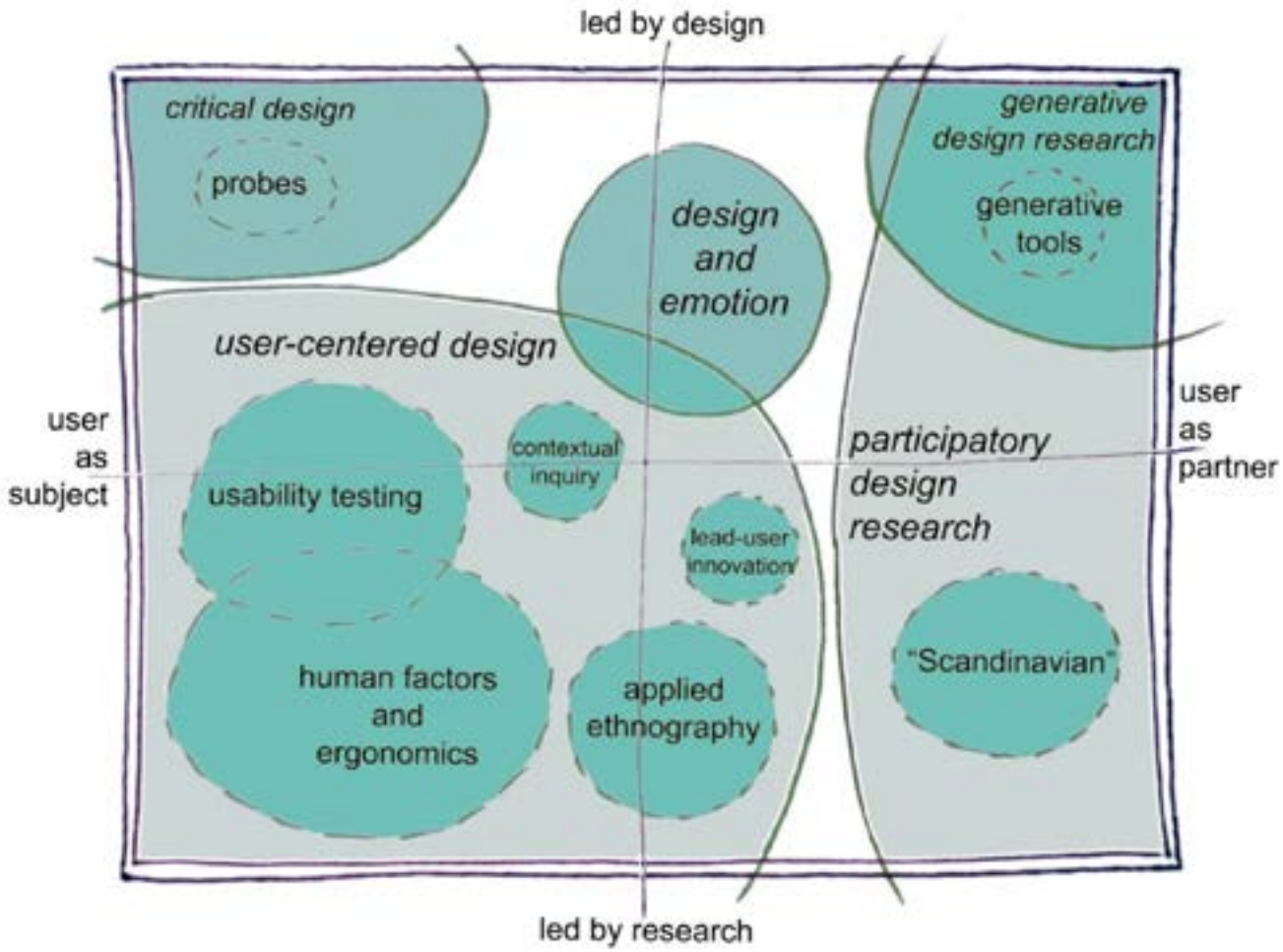
The co-design research process, from the high uncertainty of the early stages to the final release of products and services.

In co-design, the three actors of the process, designers, researchers, and users, are working together, sharing a number of tools in an iterative process.



Roles of users, researchers, and designers in the classical (left) and co-design (right) process.

In order to offer the appropriate support to the development of new ideas through co-design processes, it could be useful to adopt the co-design radar proposed by Sanders and Stappers, where the main dimensions are the role of the final user and the role of design/research in leading the development. A number of attractors are identified, where the idea could stay for a step, either for the whole design journey.



The co-design radar, where attractors are identified around dominant characters and tools of the design process.

Work methods analysis

Ariyatum, Holland, and Harrison have proposed an interesting approach to the experimental analysis of the working methods adopted by multidisciplinary teams in the smart fashion design process [21]. As they report, smart clothing domain is very complex and none of the involved experts can understand every aspect of the desired product.
They envisage a method that reconciles all aspects so they are perceived and interpreted through one point of view, as it may reduce the number of possibilities to explore. A mutual learning dialogue should be established in order to reach this common ground.

> *"if the fashion task is carried out with technological consideration and technology is created with the fashion design in mind, the smart clothing development can achieve the optimum balance between fashion design and technology. Moreover, the conflict can be reduced".*

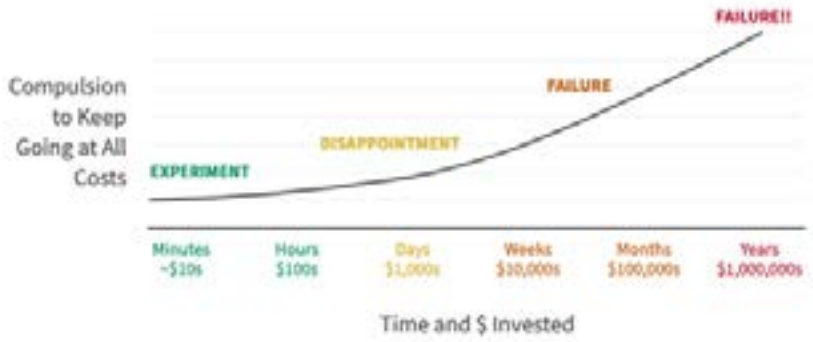
The tables, which summarize the work methods and the future trends identified by the different team members, can give useful hints to the hub facilitators. For this purpose, those are fully reported below.

Type of Discipline	Work Methods	Personal Opinions
Design Manager	This person manages D&D team which includes human factors, user interface, covers engineering, industrial design and graphic design. To avoid communication problems, all members are interdisciplinary. Their NPD process is general. It includes strategy planning, technology development, design and implementation and sale.	The team requires more disciplines from social science areas in order to look at the product from the user's point of view. Moreover, design should be placed earlier in the process. The value of the electronic product is hidden. Since the real cost is a technology that is incomprehensible for the user, the design role is very important.
Fashion Designer	In a team, a designer is usually at the top of the hierarchy. The research is similar to a process an artist uses to get inspirations. Fashion designer works with a pattern-cutter and a technician. Designer creates concepts and sketches, while the pattern-cutter and technician turn them into models	All fashion designers have radically different approaches to design. There is no accepted methodology. Thus, they are extremely intangible. Although, major advances in clothing design usually result from technological breakthrough, the industry is slow to embrace technology.
Product Designer	According to the functional approach, market and product research is important. Normally, the designer has several meetings with the clients to clarify key issues and create a plan. Although, the designers cannot change electronic configuration, they can suggest an innovative idea to engineers and solve the problems together.	This designer suggests that 'different product should be designed differently.' The priority is inherent function, user perception and target market. For electronic product, the user interface is the most important issue. Product design has less design freedom than fashion design, as many aspects limit the design.
Smart Clothing Designer	This development team includes industrial design, clothing design, textile engineering, telecoms, production, marketing, software and hardware development and sales. In the previous joint project, one partner created the concept and clothing design, the other partner designed and built the electronics and this team assembled the garment.	The fundamental problem of smart clothes development is the differences between the electronics production and the clothing/textile production. For this person, combining clothing, electronics and communication are the big challenge. As a result, the team need to (re-)organise and develop the process further
Technical Textile Designer	The process is similar to that of invention: identify the problems; study materials and structure; source out materials and test; design a number of weaves with several combinations of materials; produce the samples; test; analyse the result; redesign.	Developing technical textile is entirely different from normal textile design. The normal textile design is limited by time and trends. On the contrary, the technical textile design is a slow process with many uncertainties and unexpected problems.
	The process is repeated until the team finds the design with the right properties. During the process, designer has several meetings with the clients to exchange the ideas.	Communication is a major problem because the technical textile designer has to deal with more disciplines than the typical textile designer does.
Intelligent Textile Technicians (two interviewees)	The joint project normally includes design, business and technical people. The research is planned together, but each work is done separately. The team usually meets 3-4 times a year. In the joint-projects, the fashion design team creates the design and prototype before this team can source and apply materials to the model. They conduct user research, develop works and test.	Their research is very much from textile point of view, as they focus on materials and properties. For other research group, textiles are still like a normal textile. As smart fabrics are unable to provide their promise(s) currently, smart clothes are not functional yet. It is noted that presenting with a real model and real fabrics make the discussion between members easier.
Electronic Technician	Electronic company did not intend to develop clothes, as people would not buy clothes from electronic company. As a result, this electronic team produced prototypes and presented them to the fashion company in order to find a partner. In the previous joint project, the fashion partner created garment and its scenario, while this team designed the electronics.	Technical issues (e.g. compatibility, etc.) are still significant problems. However, the key problem is a language barrier. Electronic people do not understand the technical terms, fashion calendar and its deadline. To work with the different industry successfully, each partner should be concerned about the other industry's development and manufacturing process.
Future Trend Researcher	This team studies trends in three areas: technology, society and business, and how they affect the lifestyle. For visual strategy research, the team conducts lifestyle research in the major cities and identifies new directions. To find out the latent needs, they conduct an observation, as the user cannot visualise non-existing product	Making the results comprehensible for the design team to address in the design is very important. Therefore, this research team uses both visual and verbal form to describe them. To find new direction, it is important to look at the problem from a different angle. The key is to explore issue from both positive and negative sides.
Sportswear Designer & Lecturer (two interviewees)	The process is user-centred. As every part and pattern serves functions, the designers need to understand human body, sport activities, technical textiles and target market. In many cases, designers create concepts, make prototypes, test each part and combine them together. Some designers develop concepts and the other discipline interprets them into more functional design.	Sportswear design is fabric-driven. It is a straightforward practical approach with excitement and innovative ideas. All designers have a passion for sport and designing functional products. Sportswear design is similar to that of smart clothes, as the materials are chosen based on the properties. Purchasing criteria may be similar, as they are based on the functions.
Fashion Accessory Product Management	The team is responsible for the development of product line. Their success comes from the regular fashion trend research and close relationship with external companies.	Main challenge is to bring emotion into a technical product. Fashion and technology are equally important. New development in materials & trend interpretation is the key

Type of Discipline	Smart Clothing's Design Direction
Design Manager	The biggest challenge is looking at what technology can provide and filtering what people do not want. It is important to understand the cultural impacts and change people's perception of fashion versus product. Purchasing criteria of both products should be examined. Technology should be developed from the user perspectives. Target market, life cycle, social acceptance and sustainability should be addressed.
Fashion Designer	Future lies in collaboration between different disciplines to create a product where technology is invisible and clothing performs the functions as always with a few discrete extra functions. Development teams need to get beyond 'stereotyping creative & tekkies'.
Product Designer	Smart clothing nowadays does not look realistic because of the technical limitation. It should take functional approach and pay more attention to social acceptance. It can be a wearable item like a strap, which might be more suitable than clothes.
Smart Clothing Designer	As production methods are developed and the devices can be integrated in the fabrics, there are plenty of possibilities & opportunities. This team will continue designing and producing simple bodyworn devices. To make people take wearable and smart clothes seriously; developers should thoroughly develop useful & functional designs.
Intelligent Textile Designer	In the next 5-10 years, every piece of clothing will include some electronics. The fastest growing sector is medical products, especially with help of nanotechnology. Pressure sensor, temperature controls and entertainment area are also the interesting fields.
Electronic Technician	Integrating electronics into clothes requires a functional reason, as it leads to many technical problems. One solution is using a modular system & a universal interface which allows any device to be plugged in the garment. However, it limits the devices' functionality. The other way is producing devices very cheaply that they can be fitted into every garment. At present the direction for the mass has shifted to monitoring and healthcare. The interest moved to sportswear, as it is more experimental and innovative
Intelligent Textile Technicians	Many of the products available market have not been really useful. Moreover, they are complicated and expensive. However, many prototypes for elderly people and those in healthcare and sport area seem to be useful and have a potential market. The future lies on what people want from these clothes. At present nobody knows these latent needs.
Future Trend Researcher	Many issues need to be explored e.g. fashion vs. function, the reason(s) behind people's purchasing and using electronic devices & clothes, etc. Study from user point of view.
Sportswear Designer	The garments should work well without technology. It should be simple. Elderly people are an interesting group, as many functions are useful for them and they value things for a longer period than the younger age group. Co-branding should be considered.

Pretotyping

Pretotyping means pre-prototyping and consist of a set of tools, techniques, and tactics designed to help to validate any innovative idea quickly, objectively, and accurately[6]. The goal is to make sure that you are building The Right It before you build It Right. Pretotyping was originally proposed by Alberto Savoia, the first Google's developer engineer in 2010, and thereafter it has been perfectioned at the Stanford University [22]. This methodology can be applied during the process in order to fast verify and eventually discard the high number of ideas, which are likely to be generated during the knowledge discovery experience. As illustrated in the picture, the cost of a compulsory development of an idea gets exponential cost in time. The adoption of pretotyping will help to keep the "loose parts" in idea generation and transdisciplinary conversation, within sacrificing the project/organization available budget.



Cost of compulsory idea development accordingly to Alberto Savoia pretotyping approach.

Summer camps

A valuable approach for boosting the dialogue between artists and technologist can be gathered from the annual "**E-Textiles Summer camp**"[7] project which, since 2011, has brought together a growing network of textiles artists, designers, and researchers from across Europe, working in smart and electronic textiles. All participants have been contributing to the "**Swatchbook Exchange**", an annual physical, material open source record of emerging practices, co-created by workshop participants.
Those practices proved to be valuable for both charting the development of e-textiles, as well as providing a learning resource to grow a pan-European network of smart textile practitioners and research-led teaching for smart textiles.

It started with the **E-Textiles Summer camp** held in Borås in 2011, which gathered experts and practitioners together in one place, for one week, exchanging skills and knowledge through hands-on workshops. One of the key aspects of the Summer Camp is to facilitate personal relationship among the participants, and therefore their number has been limited to 30. The organizers also emphasize the event as an "experts practitioner's gathering", i.e. a venue where experts have the opportunity to learn each others.
The proposed practices often involve techniques that require intensive handwork, resulting in long production processes they want to call "slow", rather than "time-consuming", exalting the positive social and cultural impacts resulting from slow processes.

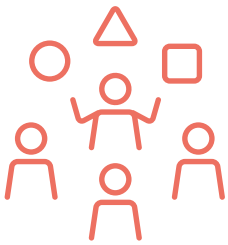
Summer Camp contains three major activities: Skillshare Workshops, Discussions, and Group Projects. The **Skillshare Workshops** are where the participants teach their skills to others in hands-on workshops. Organizers ask for a survey to all the participants prior to the event, asking which skills they want to share and which skills they want to learn. According to the answers Skillshare Workshops are arranged for the first 2 days.
The Discussion sessions are held each evening to discuss topics related to the yearly theme. The last 2 days are be dedicated to working on collaborative group projects. In parallel with the camp, the eTextile SummerSchool offers time and space to learn about electronic textiles in a series of one-day workshops held by practitioners from the field.
These workshops span knowledge and skill from traditional crafts and basic electronics to programming microcontrollers, screenprinting and actuating thermochromic pigments, designing on-body electronics and producing textile circuit-boards. At the evening everyone is invited to join a big feast, with social B.B.Q. and wine.

Collective creativity - how to learn co-creation

Edited by the **CO-CREATE consortium**, the **The Co-Create Handbook** [xx] presents a comprehensive methodology for developing train-the-trainer workshops on co-design.We suggest to approach the guide as a practical reference for organizing co-design courses and training activities. It is structured in the following sections:

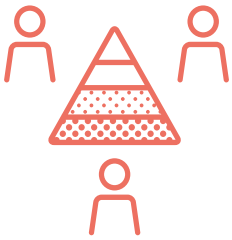
- why co-creation
- what is co-creation
- what are the benefits and challenges of co-creation
- 8 key principles for successful co-creation
- 4 key steps in co-creation
- how to prepare a co-creation workshop

The 8 key principles can be adopted as a reference for the Tech / Art trasfer co-creation actions. With this purpose, they are hey are fully reported below.



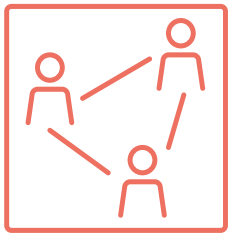
 # Skills of facilitator

= a well-trained and skilled facilitator who is able to set up the process and also to react spontaneously to unforeseen developments. The fa-cilitator needs to have an open attitude, be able to create a safe space and let people feel free to contribute in their own way. Facilitators need to be clear on what they expect from participants and how their efforts are made visible.



 # Clear needs and shared pains

= clear definition of needs of the target group, the background, aims, targets and tasks. Co-creation is a strategic choice, has strategic conse-quences and invites multiple perspectives. Everyone is an expert in their own right – by balancing professional and experiential expertise, a level playing field is created. It is also important to learn how to communicate needs and pains. This is the basis to achieve a balance and to under-stand individual motivations.



 # Building a healthy enviroment for Co-creation

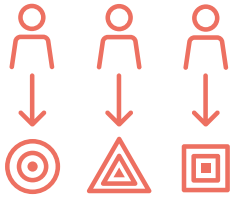
= using special tools, methodologies and framework settings. An ins-piring and open setting is crucial for bubbling over with ideas. But it is just as important to have a clear structure. Structure applies to content, space, time frame and even (if visible) rules of participation, as well as to the flexibility to adjust procedures during the co-working process whe-never necessary. In co-creation, co-working and co-participation, prob-lems like precariat and exploitation can be present. Questions of trans-parent management and money distribution should be part of the open discussion within the group.

Diversity of team

= involving all relevant and necessary stakeholders inside and outside the organisations. Co-creation is inclusive, or should rather be non-exclusive. Think about the representation you aim for, don't (only) go for the obvi-ous. It's about people, not about users or customers. Think of participants as 'active agents' rather than 'beneficiaries'.

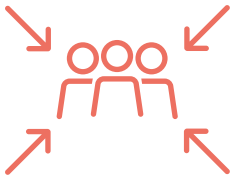
Common vision & shared values

= developing a common value and a common vision during the process. The aim of co-creation is to create shared value – together with your sta-keholders. Co-creation is an open and constructive process, where (pro-cess and/or outcome) control is shared. Co-creation thrives with shared ownership – in both results and process.



Individual roles for individual goals

= the art to involve stakeholders at the right stage of the process to en-sure a positive outcome. Co-creation is open ended. Keep people involved after the session was concluded. Give feedback on the choices you make afterwards.



Handle conflicts and interests

= setting up a process to avoid conflicts and varied interests, or acting spontaneously when conflicts pop up. It's about collective creativity – in a creative process, a different dialogue between people is started. It's not about finding the right idea, it's actually about finding a multitude of ideas. Give open and respectful feedback. Conflicts might, however, also be a tool of the process to create space for a more open communication. Conflicts help to find out what really matters to oneself or others.

Reflection and evaluation

= it's not enough just to get feedback on the choices you make after-wards, but also to evaluate and reflect on the whole co-creation process. This can provide important data for the following stages of co-creation or the next project. Also, evaluation should be long-term – following up on the results and new project developments. Projects are open ended, it is therefore important to keep an eye on their development.

The eight elements proposed by artway of co-creation process.

CoDeT and GLID

CoDeT (Collaborative Design Thinking) and GLID (Grounding, Listing, Interpreting, Distilling) methods have been presented by Maarten Van Mechelen, a researcher at Mintlab ok KU Leuven[8].

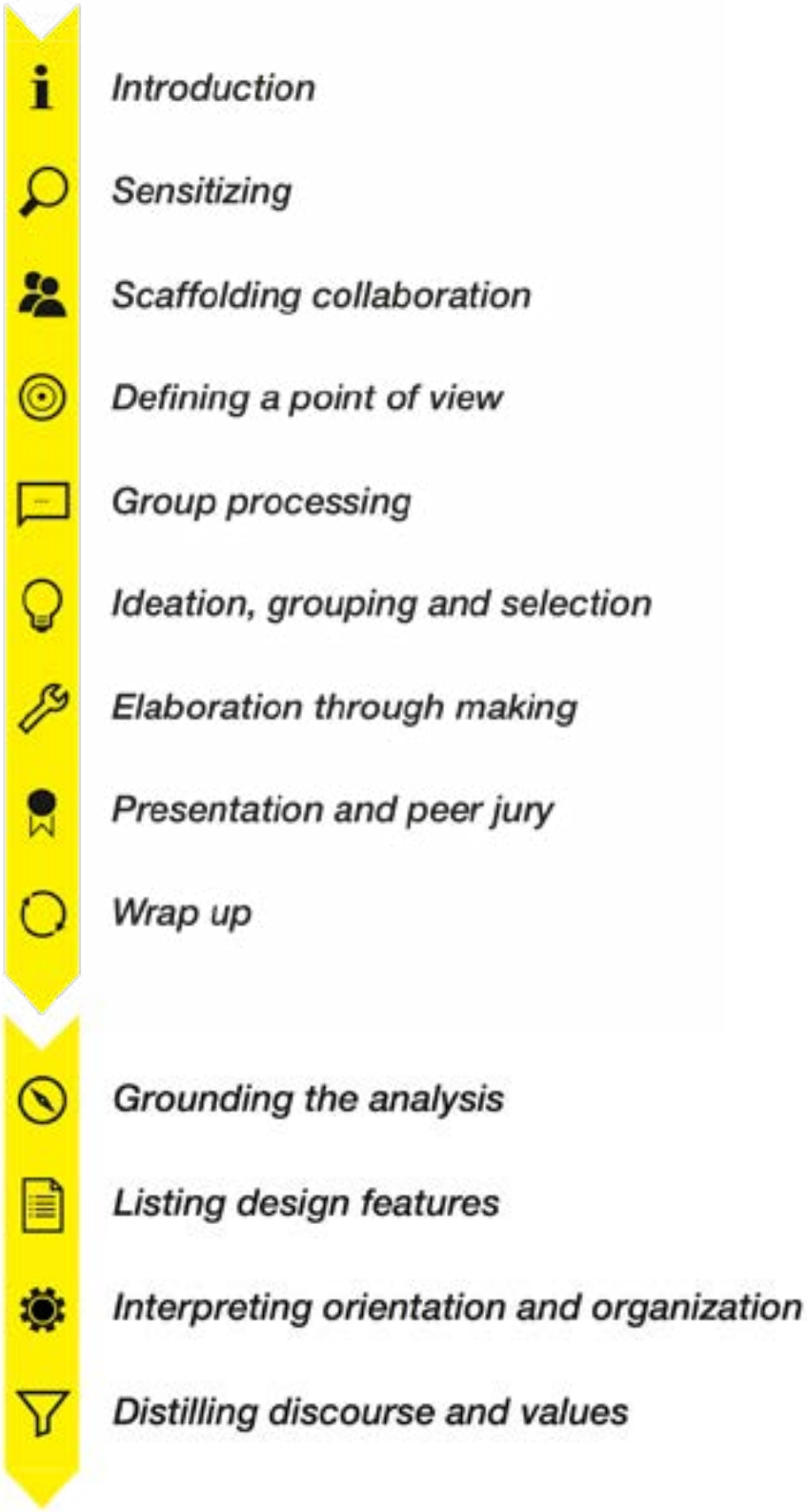
The procedures focus on organizing, conducting and interpreting co-design sessions with children, but they are perfectly fitting in the constructivist approach we have adopted in this toolbox.
[23]

CoDeT has a dual goal: scaffolding Design Thinking and facilitating effective collaboration. GLID guides the analysis of co-design outcomes resulting from CoDeT beyond the surface level of the proposed ideas. The method integrates textual, tangible and other co-design outcomes into a structured and coherent analysis. Together, CoDeT and GLID offer a holistic co-design approach to manage the early stages of technology design.

The GLID method integrates the material dimensions of co-design artifacts and their verbal explanation in a structured and coherent analysis. The method goes beyond a descriptive analysis and aims to identify the values embedded in co-design outcomes resulting from the CoDeT procedure.
In co-design activities, it is useful to go beyond participants' concrete ideas and suggestions to arrive at an empathic understanding of the values at stake in that situation. Especially at the early, fuzzy stages of design, this type of knowledge is useful to more accurately define the design problem and inform potential solutions. Following the CoDeT co-design procedure or a similar variant, a problem statement is defined by participants, who, thereafter, co-construct a solution in small teams. They thereby alternate between projective thinking (what could be), and reflection about the consequences of their projection, implicitly or explicitly negotiating the background values.
Therefore, co-design outcomes embody the negotiation and value trade-off processes and can be interpreted by multimodal semiotics in order to give feedback to the teams and improve their effectiveness.

In co-design activities, it is useful to go beyond participants' concrete ideas and suggestions to arrive at an empathic understanding of the values at stake in that situation. Especially at the early, fuzzy stages of design, this type of knowledge is useful to more accurately define the design problem and inform potential solutions. Following the CoDeT co-design procedure or a similar variant, a problem statement is defined by participants, who, thereafter, co-construct a solution in small teams. They thereby alternate between projective thinking (what could be), and reflection about the consequences of their projection, implicitly or explicitly negotiating the background values.
Therefore, co-design outcomes embody the negotiation and value trade-off processes and can be interpreted by multimodal semiotics in order to give feedback to the teams and improve their effectiveness.

CoDeT



GRID

CoDeT and GRID steps to be implemented in the co-creation process.

My creative process is based on experiment and error, exploring new forms of craftsmanship that transform traditional couture to new grounds of innovation through a multi-disciplinary approach of collaborations with artists, architects, and scientists.
Iris van Herpen

An emotional response yet can also withstand the scientific method and provide answers to questions is the ultimate manifestation of good art-science. These pieces mystify us with the complexity of their beauty, inspire us with the rich history of experimentation, and stupefy us with questions. They merge the known with the unknown in a way that uplifts. They bask in the realm of awe, mystery, and wonder. And only when there is this diversity of responses has the true objective of art-science been achieved.
Julia Borden

There is no way I could ever combine art and science, I have to choose one [...] my whole life I had experienced this conundrum. When I decided to go to graduate school, I majored in computer science to challenge myself and do something different from art. While there, I discovered that science and art could, in fact, be combined and that opened up a whole world to me.
Leah Buechley

Working in textiles allows me to physically transform technology from hard, functional, mass-produced, and progress oriented, into something soft, sensual, and intimate.
Maggie Orth

That kind of thinking, from a mathematics point of view, was discovered hundreds of years ago. Fashion needs to catch up to be able to evolve.
Mark Liu

It is time to rethink the definition and purpose of fashion as well as the materials that we use. Science brings new significance to fashion and pushes the design process to adapt to different functions, features, and systems.
Oksana Anilionyte

Technology is not the starting point of our designs, it is never about "technology" for technology's sake. Our designs begin and end with the body, or even more specifically: a moving body in space.
Pauline van Dongen

Fashion is an interface

Anouk Wipprecht

Inspiring Stories

Photo by WallpapersCraft

Fashion and technology are still two different and unconnected worlds.

Only Hussein Chakayan and Iris van Herpen, among the fashion tech artists, are considered part of the fashion establishment, as they show their collections in the London Fashion Week.
There are many interesting and inspiring projects developed in research and education centers, but there is still a lack of fashion tech products in the real contemporary fashion market. And what about the consumers, the press, the whole fashion ecosystem?

Re-Fream is about bringing these two worlds together and coming out with outstanding artifacts which enthusiasts the fashion community as well as the scientific one.

Therefore the borderline is extreme thin, and we need to concentrate our effort to find the right language, which expresses the Zeitgeist of the advanced society, a message with the right balance between function and aesthetic, science and magic, technology and art.

Here we have reported a selection of inspiring stories, including both the very recognized and the undiscovered ones.

Credits by Anouk Wipprecht.
Fashion as an interface.

Anouk Wipprecht

Anouk Wippecht is a Dutch fashion designer specialized in “technological couture”[9]. She defines fashion-tech the upcoming combination of fashion design, with engineering, science, and interaction/ user experience design.

Anouk suggests that fashion is an interface. It is part of a developing bond with technology, which will morph into personal connections with the interfaces around us. Her creations are animated by embedded intelligence in order to respond to the environment. In the Smoke Screen, for example, the wearable tangible couture has the ability to suddenly visually obliterate itself through the excretion of a cloud of smoke. Ambient clouds of smoke are created when the dress detects a visitor approaching, thus camouflaging itself by an immaterial screen. Anouk often teams up with different engineers, scientists, technologists, and companies. She believes that the implementation of collaboration is where true innovation occurs. The Intel-Edison based Spider Dress is another example of her aesthetic: sensors and moveable arms are expanding personal space, as the robotic dress attacks when somebody come too close. An original aspect of Anouk Wipprecht’s professional activity is the wide partnership with tech companies as INTEL, Autodesk, Google and Microsoft, brands like AUDI and Swarovski. She’s also cooperating with 3D printing innovators as Materialise.

BioLogic Second Skin, Tangible Media Group, MIT Media Lab. Photo: Tangible Media Group / MIT Media Lab

BioLogic

BioLogic is a research team in MIT's Tangible Media Group, part of MIT's Media Lab. The group is devoted to the concept of "radical atoms", i.e. materials that transform dynamically, which artists and designers would use to express their ideas. They envision a future human interaction with dynamic materials, not only inspired by nature but made in collaboration with nature. [10]
In the bioLogic team, they have created a radically new approach to the design of performance fabric, where biomaterials research is fully integrated with textile design . Living actuators, based on bacteria, are embedded in the textile. which is resulting in a sort of responsive second skin. "Bio is the new interface, we are imagining a world where actuators and sensors can be grown rather than manufactured, being derived from nature as opposed to engineered in factories."

Director of the lab is Professor Hiroshi Ishii, who suggested to study the behavior of bacteria Bacillus Subtilis Natto, well known from ancient times in Japan for its fermenting properties, as its cells are expanding and contracting in connection with the atmospheric level of moisture. Bacteria have been embedded into the fabric using a micron-resolution bio-printing system. In this way the fabric is transformed into responsive fashion reacting to body heat and sweat, causing bio-actuated valves to open.

In bioLogic, ideas for smart textiles are arising from scientific knowledge about the natural world, where a lot of smart materials are naturally responsive. A grant from the MIT Council for the Arts enabled bioLogic to invite fashion and product designers from the Royal College of Art, Oksana Anilionyte and Helene Steiner, to match the work on bio-actuators with aesthetic research.
The perspective is to involve a broader community, where cutting-edge technological, artistic or conceptual ideas, as well as relevant practical issues — like washing and caring - could be addressed by the wider design community who produce and use the fabric. Several fashion designers from Central Saint Martins and Parsons have already been already attracted by the opportunity to co-design application of the adaptive textile.

Danit Peleg

Danit Peleg is a young Israeli fashion designer graduated at Shenkar College of Engineering and Design[11]. In 2015, just after graduation, she decided to work with 3D printing, with the aim to create an entire garment using technology accessible to anyone. Inspired by Eugène Delacroix's Liberty Leading the People, she started playing with the many triangles present in the painting's composition, which went at the base of the 3D models.

In the summer of 2017, Danit launched a customization and personalization platform on her website, enabling customers to personalize and order the world's first 3D printed garment available to purchase online. In future, she envisages customers printing the dresses in stores, and eventually at home.

The Danit Peleg 3D team, based in Tel Aviv, cooperates with both material researchers as well as printing companies to further develop the design process, creating an alternative to the traditional fashion supply chain, reducing the environmental and social footprint. Danit Peleg provides consultation for fashion brands who are looking to implement 3D printing and delivers online virtual workshops for beginners on 3D Printing Fashion.

Danit Pelerg: Liberty leading the people collection.

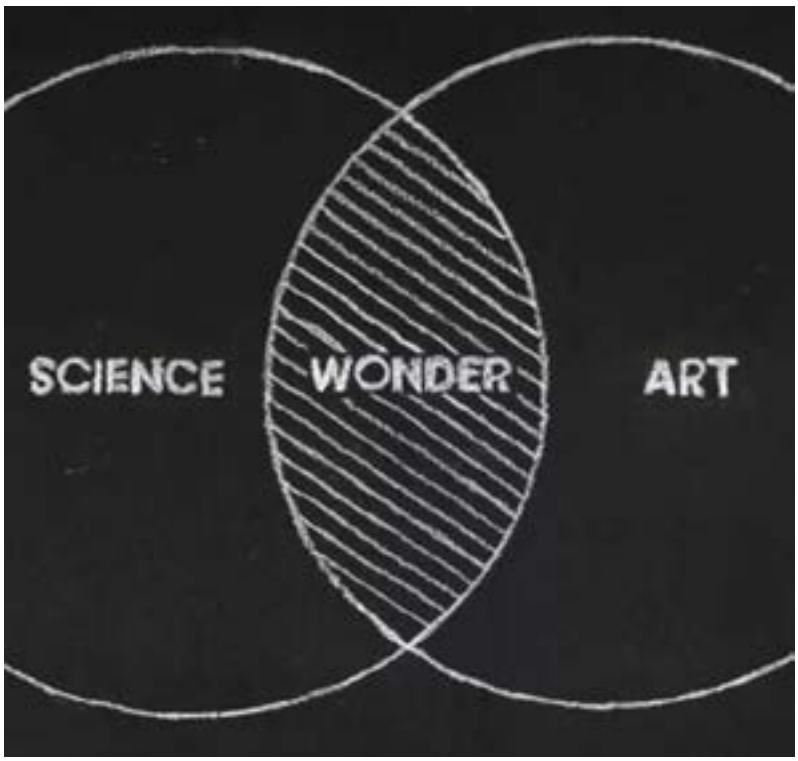
Descience

Descience is a project aimed to promote a global collective of scientists, technologists and fashion designers, providing a platform for their cooperation. **Descience** founder and neuroscientist Yuly Fuentes-Medel had the idea while attending a friend's fashion show, reflecting upon the creative process and how to open it towards a transdisciplinary approach.
With this mindset, Fuentes-Medel and the Descience team started their venture in 2014, launching a fashion show in Boston for teams including one scientist and one designer, collaborating in making dresses. They attracted 61 team from all over the world, presenting their creations.
Accordingly to Julia Borden editor of Descience blog, the key difference between art and science.

> *"lies in the direct opposition of emotion from reason. Of what is felt to be true from what has been defined to be true. Of a viewer-independent response from an answer that has been discovered via rigorous testing. Of an artist's personal process from the Scientific Method. Good art-science should provide the viewer with an equally satisfactory experience when viewed from both angles."*[12]

Thus, **Descience** wants to recreate the unity of aesthetics, ethics, and praxis because this unity is needed to face the contemporary challenges of the globalized society.
This approach requires new cognitive loops, when it is asking, for example, to look at the microscope images from the artistic point of view, as they can inspire imaginative exploration and interpretation. It is from the scientific observation that we're expanding our sight on Nature, and therefore the artistic inspiration we can receive from.
"Because the image is both mysterious and understood, abstract and precisely measured, because it so easily allows the viewer to travel between these two perspectives, it qualifies as good art-science."

Science on the runway.
Credits by Descience



Wonder at the overlap of Science and Art, accordingly to Descience

Descience is asking for piece of art that draws emotional responses, yet withstanding the scientific method, merging the known with the unknown. Accordingly to them, only when there is a diversity of responses, the true objective of art-science is achieved.
Esther Baena, conducting cancer research at the CRUK Manchester Institute in the UK, heard about the Descience competition. This urged her to reflect upon the attributes that drive a scientist to explore the world, realizing they are similar to those driving a designer to create art: curiosity, creativity, and imagination.
She was introduced to Arielle Gogh, the designer who became her partner in a typical co-creation exercise. It started with a "matching step" through a video chat, when both introduced their background and then started discussing colors and textures, which could represent malignant cell transformation. Esther was studying prostate cancer, which is graded using the Gleason system, a scale relying on histological appearance. After seven months of co-creation, tumor growth, invasiveness and progression went represented in a fashionable dress. Arielle translated into the fabric the changes in volume and colour associated with tumor growth: a wearable piece of art was visually explaining the scientist's view.
Empathy was there, supporting the co-creation journey. Arielle refers that:

> *"Esther and I both share a love for color, so I knew no matter what our garment looked like it was going to be colorful. Esther encouraged me and pushed me to think beyond the confines of my usual oeuvre. She was supportive of my sketches, which maintained the purity of her research. This included my dyeing experiments as well as her genuine belief in our project – even in the early, experimental phases. Every time after we video chatted, we had new ideas and could not wait to share more inspirational cancer cells and tissue images, dress sketches, and fabric dyeing results with each other. I was extremely lucky to work with someone who shared the same passion and enthusiasm for the project."*[13]

Hussein Chalayan

Hussein Chalayan is a Cypriot-born Turkish fashion designer.[14]

Chalayan's innovative mix of design, science, and art in creating his fantastical seasonal collections has won the designer significant acclaim and exhibitions in some of the leading design and art museums around the world. The seminal designer's futuristic designs have included dresses containing moving airplane parts, a robot dress loaded with Swarovski crystals and Tyvek garments that resembled furniture and could be folded down to envelope size. They have been showcased in museums such as the Palais du Louvre, London's Design Museum, the Metropolitan Museum of Art in New York and the Museum of Contemporary Art in Tokyo.

In collaboration with Intel, Chalayan presented a piece of wearable technology that enables an Insecurity Projector. The sunglasses contained sensors and microphones that monitor heart rate, breath rate, and EEG "brain waves." These transmit to chips implanted in a handsomely chunky belt with a two-line grid of stainless steel studlets on its back. A projector in the side of the belt beamed visual representations of each emotional measure on the wall alongside the runway.

The projection included pixelated dancing figures the more nervous the wearer, the faster they danced.

The Hussein Chalayan and Intel connected accessories on the runway at Paris Fashion Week. Photo by Intel.

The cloth is developed in parallel with the devices. The roses, grids and other pixelations were variously incorporated as overt decorative motifs. Chalayan has developed a resistance approach against image-oriented fashion industry, through his conceptual attitude by deconstructing the meaning of the clothes, in order to re-semantify them and change their ontology.

He develops different conceptual paths where the epicenter is an inter-disciplinary design process in which he does not draw any distinction between the world of clothes, objects, images, spatial environments, and technology.

Iris van Herpen in her atelier in Amsterdam. Photo by Maartje Geels, accessed at Trouw.nl

Iris van Herpen

Iris van Herpen is a Dutch fashion designer widely recognized as one of the game-changer in the relation between fashion and technology.[15]
Since her first show in 2007, she has been combining the most traditional and most radical materials processes into a holistic aesthetic approach.

Iris van Herpen has been a frontrunner of the integration of 3D fabrication technologies into fashion design. After earlier works, which relied on low-tech solutions, she gathered a growing network of technologists contributing to high-tech innovations to her projects.

In the Crystallization collection, launched in 2010, she used digital printing for the first time. After the presentation of a digitally printed exoskeleton (Capriole 2011), in 2012 she was inspired by the work of Philip Beesley, founder of Living Architecture Systems group (LAS) at the University of Waterloo, for the Hybrid Holism collection (2012). Collaboration between van Harpen and Beesley followed with the Voltage (2013) and the Magnetic Motion collection (2014), the last originated by a residency at CERN in Geneva. In Dome Dress (2017) they have seamlessly integrated more than 300 laser-cut zinc-coated steel pieces, with hand-molded components pieces. The creative process behind Dome Dress and its presentation in Paris for Aeriform, has been captured by Stylianos Pangalos in an inspiring video[16].

Van Herpen's work has acquired by the Metropolitan Museum of Art in New York, where she was part of the Manus x Machina: Fashion in an Age of Technology show in 2016. Among the awards, it's worth to mention the Grand Prize of the European Commission for STARTS (2016).on experiment and error, exploring new forms of craftsmanship that transform traditional Couture to new grounds of innovation through a multi-disciplinary approach of collaborations with artists, architects, and scientists."

"Within my work, I search for symbiotic relationships; looking at the hidden beauty at the intersection of precision and chaos, art and science, the artificial and the organic, that are blending into infinite hybrids. I am seduced and obsessed by the behavior and the misbehavior between the body and her architecture, her shelter. It's the interaction between the two that fascinates me, that challenges me to think beyond today's definitions of a garment. The endless mysteries within nature create a huge influence on my work. Through biomimicry, I strive to find the forces behind the forms in nature, and how I can re-sculpt the female form. Seeing water move, for example, it makes me feel insignificant as an artist as nature is the most ingenious artist itself, but at the same time, her metamorphoses are my muse to see new forms of seduction and a more diverse and conscious fashion for the future. My creative process is based on experiment and error, exploring new forms of craftsmanship that transform traditional Couture to new grounds of innovation through a multi-disciplinary approach of collaborations with artists, architects, and scientists."

Julia Körner

ulia Körner is an Austrian born architect working at the convergence of architecture, product, and fashion design. During her long lasting and successful career she specialized in additive manufacturing and robotic technology.
Amongst other Parisian Haute Couture houses, she collaborated with Iris Van Herpen and Materialise on three 3D printed dresses for the IVH Haute Couture Show in Paris between 2012-2014. The structure of the garments reveal a highly complex, parametrically generated, geometrical structure.

Julia's Kelp Jacket piece, shows a structure of multiple layers of thin woven lines to animate the body in an organic way.

Credits: Julia Körner, Kelp Jacket, Sporophyte Collection
Photo by Ger Ger for SCHÖN! Magazine 2015

Her career brings her pieces into the National Geographic Magazine, to the Venice Biennale, and institutions such as the FRAC Centre in Orleans, the Art Institute of Chicago, the High Museum of Art in Atlanta and the Metropolitan Museum of Art in New York.

Körner's work is an example of how artistic design can coexist with fashion. For example talking about the Oscar-winning project of Black Panther, that provided an opportunity to show how her work is influenced by architecture while grounded in fashion as well. "I have a background in architecture, but see myself as a designer working across disciplines, between fashion, product, and installation scales. For me, fashion is architecture in its smallest scale. The techniques and methods I use to design are the same no matter what scale. The body is my site."

Recognized today at the forefront of 3D printed innovative designs, Julia's work stands out at the top of these disciplines.

Leah Buechley

Leah Buechley received a Ph.D. in computer science from the University of Colorado at Boulder after a BA in physics from Skidmore College in Saratoga Springs, NY.

At both institutions, she also studied dance, theater, fine art, and design. She devoted her work to the exploration of possible integrations of electronics, computing, art, craft, and design.

While being an associate professor at the MIT Media Lab, she founded and directed from 2009 to 2014 the High-Low Tech group[17], whose spin-off is the design firm Rural/ Digital[18] that explores playful integrations of technology and design.

High-Low Tech group was working at the intersection of computation, physical materials, manufacturing processes, traditional crafts, and design. Leah has been engaging diverse audiences in designing and building technologies, situating computation in new cultural and material contexts, and developing tools that democratize engineering and empower end-users. One of the remarkable outcomes of Leah's work is the LilyPad Arduino, a construction kit specifically designed for sewable electronics.

"There is no way I could ever combine art and science, I have to choose one [...] my whole life I had experienced this conundrum. When I decided to go to graduate school, I majored in computer science to challenge myself and do something different from art. While there, I discovered that science and art could, in fact, be combined and that opened up a whole world to me."

Artwork from Rural / Digital

Maggie Orth

Maggie Orth has been pioneering the possible intersections between fashion design and technologies since the '90.

At her studio in Seattle WA, Maggie developed interactive art and design works in the context of her company, International Fashion Machines, Inc. (IFM), where she focused on developing the creative, technical, and commercial aspects of electronic textiles. Maggie holds a Ph.D. in Media Arts and Sciences from the Massachusetts Institute of Technology, Media Lab, a Master of Science from MIT's Center for Advanced Visual Studies, and a BFA from Rhode Island School of Design.
She has completed two certificates in non-fiction and fiction writing at the University of Washington.

She believes we cannot solve the complex problems facing today's world without innovation, collaboration, and interdisciplinary thinking. Here we report an extensive excerpt of her "artist statement", published in 2009 and available on her personal web page[19], as we consider it paradigmatic for the research on art and sci/tech in the fashion domain.

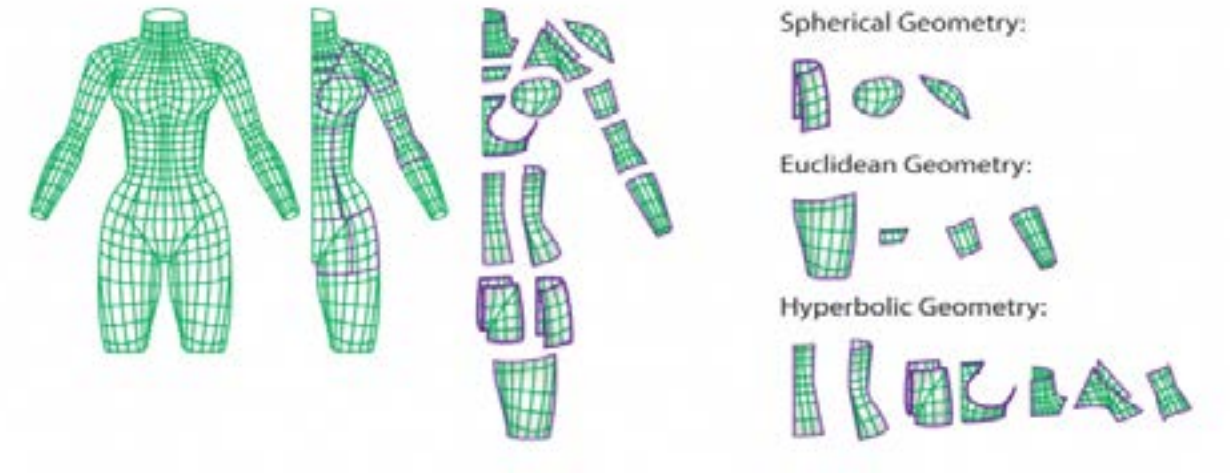
Credits by Maggie Orth.
Musical Jacket, 1998 - Machine embroidered resistive yarns, metallic silk organza power and data bus, custom sensing electronics, speakers, custom MIDI synthesizer, and batteries.

"The materiality of my work is essential to its meaning. Electronic textiles juxtapose two seemingly antithetical worlds: textiles, which are stereotyped as handcrafted, decorative and feminine; and computer technology, which is seen as mass-produced, functional, and male. Working in textiles allows me to physically transform technology from hard, functional, mass-produced, and progress oriented, into something soft, sensual, and intimate. Electronic textiles allow me to handcraft my computational medium, creating a circuit and its electrical properties, like resistance, simultaneously with aesthetic design. Handcrafting computational media aligns my work with arts and crafts practices, which seek a deep understanding of the medium through physical process. Adding electrical function to decorative elements repositions the decorative, which is stereotyped as a lesser feminine artistic practice, and invigorates it with new creative questions of interactivity. Electronic textiles allow me to place high-tech in the service of the creative and sensual, reflecting my belief that making and experiencing aesthetic objects is an essential part of the human experience.

My color changes textiles layer woven textiles, printed inks, software and time. In the gallery, the pieces begin when the viewer presses a button. Saturated color, hidden electrical elements, weave structure, and patterns are slowly revealed. Perception is challenged as background and foreground shift, and the static relationships of the compositional elements change. The experience is cumulative, quiet, and reflective, the opposite of most screen-based media. Time in my work is experienced on many scales. Initially, the software creates immediate changes which reflect weaving and yarn spacing. Over a few minutes, these become bold, compositional color elements. Over days and weeks, these changes become permanent, creating new visual elements on the piece. Viewers that return to the gallery days later see a subtly different piece and the work that enters the gallery is not the same when it leaves.

The process of creating these works is one of revelation and relinquishing of authorship. Textile panels are woven with resistive yarns, and then printed thermochromic inks, which are dark and unsaturated. During the printing, I am only able to imagine the color change effect. I then connect control electronics to the textile and begin composing expressive software, which sends current to different parts of the textile, causing the resistive yarns to heat up and the fabric to change color. It is at this point that I experience the color change effect and see how the woven resistive yarns interact with saturated color and software.

My interactive textile and light pieces explore the hidden properties of textiles, including structure and color (which are revealed through light transmission), and electrical and tactile properties (which are revealed through touch). These works combine light with tactile and soft textile sensors. When the viewer touches the textile sensor, a small charge flows through the viewer's body to the ground. Electronics sense this change and cause lights to dim or adjust, revealing the color and pattern of textiles. The experience of the viewer is immediate and sensual and brings to the fore the electrical nature of our bodies. Viewers can use touch to change the pieces locally and immediately, or slowly create pattern and color effects over a larger surface. These works are made with a broad range of textile processes, including machine embroidery, hand tufting, and woven pile, each of which creates different tactile and light effects."



Mapping the body. Mark Liu moved from Euclidean to non-Euclidean geometries.

Mark Liu

In 2004 Mark Liu was studying for his Bachelor of Design in Fashion and Textiles at the Faculty of Design, Architecture and Building (DAB) at the University of Technology of Sydney[20]. Instead of dropping subjects like maths and science to be more concentrated on the mainstream fashion design activities, he decided to explore at the Faculty of Science, how new materials emerging from nanotechnology could be part of his creative process.

"At that time, there were only about 10 books on nanotechnology in the entire UTS Library and the information that was there was really technical, written by physicists. But, I was more interested in how nanotechnology could affect fashion, such as designing self-healing clothing, fabric that changes color or that you don't have to wash."

After the degree at UTS, Liu moved to Central Saint Martins College in London, where he developed a concept of zero-waste fashion, where the pattern cutting is conceived as a jigsaw puzzle, so no fabric is wasted. He has been exhibiting at fashion shows as well as in science museums since the game-changing strategy is based upon mathematics and geometry.

> *"People thought you could use traditional techniques and just whack patterns together to create zero-waste. But, the more I tried the more the system just started falling apart and I needed an alternative system. So, I cheated: I started borrowing concepts from mathematicians; and the more I did this the more the traditional way of patternmaking started falling apart. Until I had this one realization, which would influence the rest of my research: there are basically three different sets of geometry going on when you make a garment and fashion designers were only using one form of geometry – the geometry of flat surfaces. But, they're using it to measure curved surfaces, which creates all sorts of problems and explains why clothing sometimes doesn't fit even if you take perfect linear measurements. That kind of thinking, from a mathematics point of view, was discovered hundreds of years ago. Fashion needs to catch up to be able to evolve."*

Accordingly to Liu, everything changes when you look at the curves of the human body the way a mathematician would look at equations. That means modeling in a quantitative framework. Instead of applying the traditional pattern making, where designers take linear measurements of the body to shape those into a pattern, he introduced a new pattern making process based on non-Euclidean geometry in cooperation with UTS's Senior Lecturer in mathematics Mary Coupland.

> *"Fashion design is actually very technical and more related to maths and science than most people would think. You can't have one without the other."*

Credits by Jessica Rosenkrantz, Nervous System.
Kinematics dress fabrication at Shapeways.

Nervous system

Nervous System is a design studio of Somerville, Massachusetts, that works at the intersection of science, art, and technology[21]. Founded in 2007 by Jessica Rosenkrantz and Jesse Louis-Rosenberg, it has been pioneering new technologies in design, especially generative systems and 3D printing. Jessica Rosenkrantz is an artist, designer, and programmer graduated from MIT with degrees in biology and architecture in 2005. She studied architecture at the Harvard Graduate School of Design from 2005 to 2008 before founding Nervous System. Jesse Louis-Rosenberg is an artist, computer programmer, and maker. He studied math at MIT and previously worked at Gehry Technologies in building modeling and design automation.
The studio takes inspirations from natural forms and processes, which are mapped into generative processes.

That results in interactive systems, responding both to changes in specific variables and to physical inputs. The work is released online to enable customers personalizing products and other manufacturers to adopt the same approach.
Nervous System has released Kinematics, a 4D printing approach that creates complex, foldable forms composed of articulated modules. Kinematics combines computational geometry techniques with rigid body physics and customization. Any three-dimensional shape can be folded into a flexible structure, fabricable using 3D printing. This allows large objects to be printed and also the production of patterned wearables that conform flexibly to the body[22].

> *"We created Nervous System to explore a design approach that relates process and form in a context of interactivity and openness. Our trajectory focuses on generative design methods using both algorithmic and physical tools to create innovative products and environments.*
> *Formally, we are attracted to complex and unconventional geometries. Our inspirations are grounded in the natural forms and corresponding processes which construct the world around us. From coral aggregations to interference patterns, a study of natural phenomena is an essential ingredient to our design process."*

Wearable solar coat by Pauline van Dongen.
Credits by Mike Nicolaassen

Pauline van Dongen

Pauline van Dongen is a Dutch fashion designer pioneering the integration of wearable technology in garments.
Through interactivity, she mediates the human body with the surroundings, introducing elements of change, movement, energy, and perception.
In this sense, for Pauline technology is not a mere tool, but it becomes part of the aesthetic expressivity. It is the body that drives the appearance of the garment and it is the garment that isactively playing on the body.
The wearer is therefore connected with the cloths at an intimate and intuitive level, experiencing the "naturalization" of technologies.
Pauline actively collaborated with Christiaan Holland from the HAN University of Applied

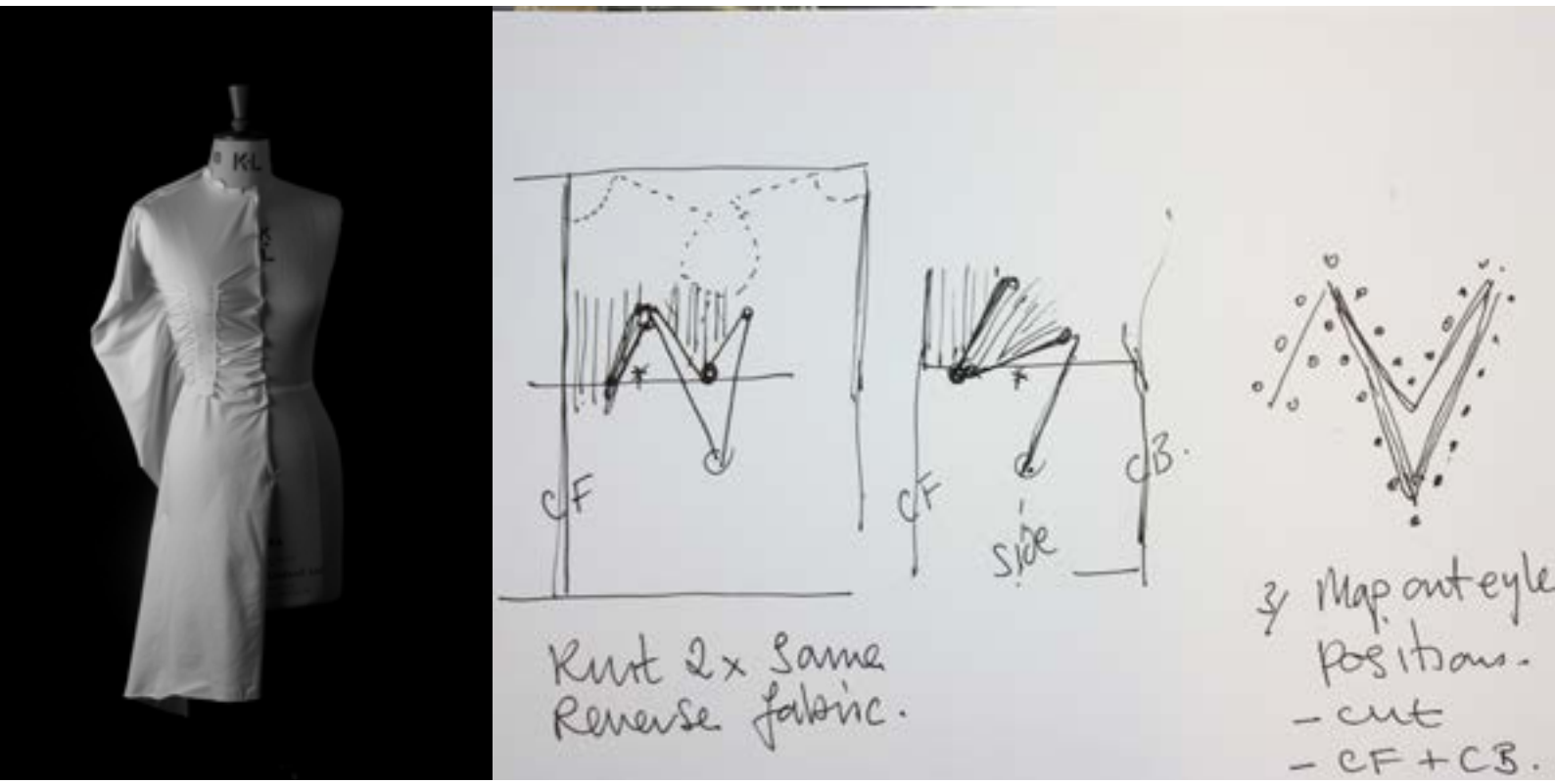
Sciences and the solar energy expert Gert Jan Jongerden in developing the concept of solar fashion. This interdisciplinary research explored new forms of embodiment and embodied experience, considering, with a scientific approach, the materiality of the textile and the technology involved in empowering the embedded electronics by solar energy. The first garments created included a wool and leather coat with 48 rigid solar cells and a wool and leather dress with 72 flexible solar cells. In both cases, the cells can be hidden when the solar radiation is not available.

Project Jaquard: textile as an interface.

Project Jacquart

The project Jacquart[23] is developed by the **Google Advanced Technology and Project** (ATAP) group. ATAP's projects usually combine technology and science, requiring a certain amount of novel research to create a marketable product.

This project, coordinated by the interface expert Ivan Poupyrev, delivers a platform for embedding sensors and feedback devices in fabrics and clothing in ways that seem natural and comfortable. It encompasses techniques for creating fashion fabrics with conductive fibers woven into them, plus small, flexible computing components and feedback devices along with software APIs that applications can use to exchange data with the garment. One key issue was to propose novel interactive textile materials that can be manufactured inexpensively using existing textile weaving technology and equipment than could reduce the time to market. ATAP launching the project in 2015, announced the cooperation with Lewis Strauss, the famous jeans brand manufacturers. After two years the technology is now available on the Commuter series denim jackets[24]. This allows a portion of the clothing, the left cuff, to take touch inputs from your hand and translate them into input controls for your smartphone, with the help of a Bluetooth-powered dongle stored in the cuff. Those controls include music playback and some simple navigation pings within Google Maps, among other minor tricks.



Sketches and prototipe.
Photos by Rihan Solomon

Rhian Solomon

Rhian Solomon[25] is working at an intersection between material culture studies, medical anthropology, and design. Her artworks explore emotional and technological relationships between skin and cloth, the body and dress - investigating skin as the interface between material and emotional worlds[26].

Her projects have been commissioned by The Wellcome Trust, The British Association of Plastic Reconstructive and Aesthetic Surgeons, Arts Foundation, The Leverhulme Trust, and have been presented at Nike Design Kitchen, The V&A and Maggie's Cancer charity. Narratives emerging within her practice inform the early stages of broader design research where she's brokering interactions between medical, material and design sectors during early phases of wearable product development.

She launched OurOwnsKIN, a joint venture with concept development footwear designer, Liz Ciokajlo, which has been funded by Innovate UK, Knowledge Transfer Partnership and Arts Council England. The research program sKINship looks to promote experimental collaborations between the disciplines of reconstructive plastic surgery and pattern cutting for fashion.

By exploring points of commonality and contrast between these subjects, new practices are informed both in the design and planning of surgical procedures and garments.

As a design facilitator, she's moving at the edge of complex ecologies of social and collaborative innovation involving designers, physicians, surgeons, experts in materials, and patients and surgeons during co-design activities. The body acts as a meeting place, and materials as a medium, for sharing phenomenological and biomedical perspectives of illness and treatment for cancer.

WIM

WIM is a celebrated experiment in fashion design, promoted by students of Royal College of Art in London, who experimented 'smart material systems' for useful applications of haptic technology. WIM is the prototype of a dress delivering haptic sensations across the body, conceived by the artist Kate McCambridge, the material designer Jun Kamei and the design engineer Jacob Boast, in collaboration with the Abnormal design studio[27] of Duncan Carter and Mick Geerits for the sound engineering. The scientific background of WIM is about neuroplasticity and smart materials. The prototype embeds electro-active polymers (EAPs), which are able to deliver sensory stimulation to the user, who is driven into a sequence of movements.

Performer: Makiko Takashima; Sound Design: Duncan Carter;
Design Engineer: Chris Rowley; Fashion Design & Construction: Oksana Anilionyte;
Fashion Design: Audrey Gaulard; Photography: Ruby Rossini

The result is a haptic-based language, which can assist the choreographing direction and coordination in dance performance[28]. The sound dimension has been integrated, too, as the surround-sound piece was conditioned by the exchange of messages among the choreographer to the dancer's garment. The perspective applications can support new methods for neuro-motorial rehabilitation and training. The fashion design was a collaboration between the hybrid designer Audrey Gaulard and Oksana Anilionyte, a young artist born in Turkmenistan and raised in Lithuania.[29] She's usually partnering with scientists in her work. Fluid Sense collection is arising from her interaction with MIT Media Lab: she was researching the way that mood and feelings have a correlation with the temperature change in different parts of the body and, after lots of trial and error as well as work in the lab at UCL in London, she came up with the new material a liquid-like garment that melts into heads, necks, and torsos, creating a second skin with pastel patterns.

Collaboration is key to innovative work as different members bring new ideas, perspectives, and skills. As a designer, I found interdisciplinary collaborations inspiring as I got to meet scientists and engineers and understand the way they think and see the world. It has been fascinating to translate new materials and scientific processes into a visual project that everyone can appreciate. It helped me to see fashion from a different perspective and question how we can merge the worlds of fashion and science. I strongly believe that we need to work together with science and technology to create a change in the fashion world. It is time to rethink the definition and purpose of fashion as well as the materials that we use. Science brings new significance to fashion and pushes the design process to adapt to different functions, features, and systems."

Places and projects to look at

Photo by onlyyouqj on Freepik

PLACES

This map identifies some of the most active places in bridging art and sci/tech in the fashion domain. It's aimed to help in finding partnerships as well as geographical sweet spots to follow.

Ars Electronica, Austria

Ars Electronica[30] is a festival, an award, a museum center with a permanent presentation and production platform, a permanent experimentation laboratory on art and technology. These divisions inspire one another in order to create futuristic visions in a unique, creative feedback loop.

Biotechnology and genetic engineering, neurology, robotics, prosthetics and media art are juxtaposed on equal terms, and form experimental arrays conducive to testing ways in which we might be interacting and communicating with our surroundings and other human beings in the very near future, and getting an impression of what these changes will mean for us and our society. With the STARTS iniziative, featured in the next section, Ars Electronica in collaboration with Bozar and Waag has launched a prize to select the most pioneering collaborations and results in the field of creativity and innovation where science and technology intersect with the arts.

Among others projects inspirting new pathways and possibilities in the fashion domain, we mention Textile Reflexes GenCloth and Closed Loop Smart Athleisure Fashion.

AUT University Textile + Design Lab, New Zealand

The Textile and Design Lab is a hotspot in combination of aesthetic and technology approach in textile and clothing design. It was established in 2006 and as a resource within AUT's Faculty of Design and Creative Technologies. The lab aim is supporting research with both internal and external partners, sharing knowledge with students, and creating mutually beneficial partnerships with designers and businesses. The lab is home to a suite of cutting edge design and programming systems, flatbed knitting, digital printing and non-woven technologies. Much the current R+D activity is in the area of functional textiles in which conductive fibres and yarns are integrated into materials to provide electronic circuitry and sensors. Other areas include 3D knit design, digital textile design and printing, needle felting, digital supply and distribution chains, sustainability, materials development and resource development for teaching and learning.

FabTextiles - IaaC, Spain

The Fab Textile[31] is part of The Institute for Advanced Architecture of Catalonia (IAAC), located in Barcelona, a centre for research, education, production and outreach, with the mission of envisioning the future habitat of our society and building it in the present. The Lab is an experimental and experiential centre where one learns by doing, through a test methodology that promotes real solutions. FabTextiles is developing and implementing a new approach on to how create, produce and distribute fashion elements, by using distributed manufacturing infrastructures and knowledge networks. This educational and pro-research work, by recycling, hacking and sensing human body and culture, creating feedback loops with project development, where materials, aesthetics and customisation play equal and important roles. FabTextiles offers a cross-disciplinary education and research platform, where production and culture through advanced technologies are making impact in the way we think and act towards the fashion industry.

MIT Media Lab, US

The MIT Media Lab is an antidisciplinary research laboratory at the Massachusetts Institute of Technology. Its research does not restrict to fixed academic disciplines, but draws from technology, mediascience, art and design. Media Lab's research groups include neurobiology, biologically inspired fabrication, socially engaging robots, emotive computing bionics, and hyperinstruments, leveraging the best that technology has to offer, and connecting technology back to the social and the human.

Inspiring research such SensorKnits (three classes of textile sensors exploiting the resistive, piezoresistive, and capacitive properties of various textile structures enabled by machine knitting with conductive yarn or bioLogic, featured in the previous section, represent how diverse backgrounds including design, art, science and engineering can produce disruptive innovation.

RCA, UK

The Royal College of Art (RCA) is a public research university in London. This postgraduate art and design academy plans to "reverse the current orthodoxies" by placing artists and designers alongside scientists and engineers at the outset of their research, rather than as an afterthought. The leading

art and design school plans to add courses focused on topics like nanotechnologies, robotics, and machine-learning to its offering, as well as embedding scientific collaboration into its existing postgraduate programmes. In 2017, thanks to the famous fashion brand Burberry, RCA opened Burberry Material Futures Research Group[34]. This new team is intended to be the first explicit 'STEAM' (Science, Technology, Engineering, Arts, Mathematics) research lab at a traditional art and design university, and will promote a design-led disruptive research environment for the development of new approaches to innovation in materials and applications.

University ARTS, Finland

Aalto University operates around the combination of four core competences in the fields of ICT, materials, arts, design and business together with three grand challenges related to energy, living environment, and health. In spring 2015, the Fashion/Textile Futures[33] research group was established at Aalto University School of Arts, Design and Architecture (ARTS) to explore new perspectives on design research through materials, textiles, clothing, and fashion. Although its strong research focus is on sustainable design, the group members' research activities and strengths encompass material-based research, creativity studies, practice-based research, and strategic fashion and textile management. Four driving forces of the future of textiles at Aalto ARTS include: (a) an increasing demand for more sustainable products and systems; (b) the ongoing development of new materials and production technologies; (c) an increasing use of textile structures at different scales, from architecture to the nanoscale of healthcare applications; and 4) the integration of textiles and electronics. All these developments have triggered emerging interest in textiles from outside the traditional textile industry, creating new opportunities for textile design and engineering.

University of Borås, Sweden

The field of textiles and fashion is among the areas in which the University of Borås, through the Swedish School of Textiles[32], has national responsibility for both the development of the artistic perspective and the collaboration between art and science.

The Swedish School of Textiles is based in the Textile Fashion Center, which houses the prestigious Textile Museum of Sweden and the Fashion Incubator, which is designed to create the appropriate conditions for nurturing new textile and fashion entrepreneurs. The ground floor is home to the Fashion Gallery – a place devoted to help fashion companies working together. Research is conducted on customized clothing production, circular fashion, the relationship between body, material, and movement, and dying textiles without water. One flagship initiative is about Smart Textiles, which works on using the textiles of the future to improve people's everyday lives, as well as to provide benefits to the industry, the healthcare sector, and the environment.

University of Technology of Sidney, Australia

The UTS could be considered as one of the major education institution, where an interdisciplinary approach is addressing the relationship between fashion practice and conceptual thinking, with a special emphasis on textiles and emergent technology. The school's resources include 3D printing, animation studios, digital fabrication studios, robotics and two specialist fashion and textile studios.

Through a dedicated section called Transdisciplinary Innovation projects[36], students investigate integrate data, information, tools, techniques, perspectives, concepts and/or theories from two or more disciplines exploring the integration of the handmade with emerging technologies, including: Electronic Fashion, Interactive Interfaces, PhotoVoltaic Textiles, Biomimicry, Architectonic Structures, Smart fabrics, Nano fabrics, High Performance Textiles, and Zero Waste. Underpinning these is a critical social consciousness towards ethical design practice and issues and questions around sustainability.

UoA - London College of Fashion and Central Saint Martin College of Art and Design, UK

London College of Fashion in UoA, is one of the leading school that teaches future designers and fashion leaders to disrupt the industry with traditional and digital skills. The school offers a vast range of courses from artisanal footwear fabrication and bespoke tailoring to advanced research in 3D effects and wearable technology. Moreover, next to training facility, the London College of Fashion has established with Microsoft an incubator program focused on student innovation in three areas: mixed reality, artificial intelligence (AI) and the Internet of Things (IoT).

Central Saint Martins is a world renowned arts and design college of University of Arts. CSM has pioneered radical innovations in art, fashion and design teaching and learning. Its influence feeds into the arts educational system, culture, industry and mainstream. The school nurtures “the free-thinkers, the mavericks, the people who think outside the box”. Both the colleges are very active in national and international projects and initiatives pursuing the bridge between art and science.

WAAG Society, The Netherlands

Waag Society[35] is an interdisciplinary non-profit media lab researching and developing new technology, art and culture. Its mission is to provide meaning and give direction to the role of technology in society. In interdisciplinary teams and in close co-operation with end-users it develops technology that enables people to express, connect, reflect and share information, emotions and responsibilities. Founded in 1994, Waag Society is part of the Dutch national infrastructure for the arts and culture, and a well-known participant in national and international collaboration programmes. Waag Society performs user research, is involved in co-creation practice and develops personal, and location based technologies. Waag developed, under the H2020 project TCBL, the Bioshade process, which employes bacteria in dyeing, as an alternative to chemical dyes and energy-consuming dyeing methods.

PROJECTS

The following section is reporting a list of significant projects, which explored social and product innovation via co-design processes between artists, designers and technologists.

https://commons.wikimedia.org/wiki/File:Gdansk_street_art.jpg

ArchInTex

The ArchInTex European Training Network[37] aims to support young researchers working in the crossroads between architecture, interaction design, and textiles. The network is exploring a new expression of living in adaptive and responsive environments, connecting the scales of the body, the interior, and the building, searching for new ideas of material thinking and design thinking with an emphasis on sensitive design expressions for a reflective living.

A cross-disciplinary network of researchers, supervisors, research methods, and infrastructure for experimental design research is ranging from fine art, fashion design, and textile design, via industrial design and architecture, to materials research and interaction design. The broad foundation of the initiative provides with a unique opportunity to take experimental research projects all the way from the initial idea to scaled-up models and prototypes ready to exhibit and try out, as well as a to relate fundamental research to development projects which covers all forms of living from a near-field to a far-field perspective.

BrainHack

The BrainHack Project[38] aimed to connect scientists, artists and the general public who are interested in human-brain-generated signals. The BrainHack Project's main goal was to inspire both scientific and artistic communities to use the BNCI (Brain and Neural Computer Interfaces), to engage with all the different facets of brain research. Most of the BNCI devices are designed to read and record the EEG – electrical signal emerging from brain cells' chemical communication as measured non-invasively from the scalp. These are the most popular and accessible of all the tools used for imagining biological signals, as well as the easiest to use in a variety of settings, hence they are highly convenient for both field research as well as in the creation of music or interactive installations. The project was structured in a series of hackathons where scientists, artists, technology providers and entrepreneurs together worked collaboratively on innovative brain-related projects using BCI (Brain-Computer Interface) technology. The results of these interactions were collected in a GitHub repository (already available) that contains basic information about EEG signal acquisition, processing and analysis, and about possible hardware and software options. The core of the repository was created by BH hackathons' participants and everyone can contribute.

CHEMARTS

CHEMARTS[39] is an interdisciplinary collaboration between two Aalto University schools—School of Chemical Engineering (Aalto CHEM) and School of Arts, Design and Architecture (Aalto ARTS) focusing on biomaterials, including sustainable textile materials and processes. Accordingly to the CHEMARTS team, innovations flourish in multidisciplinary environments and require a deep understanding of textile production technology as well as specific knowledge of how textiles are and could be used for different purposes. Thus, CHEMARTS has two main objectives: to inspire future designers and material scientists to work together and to create novel sustainable biomaterial innovations for future business development. The tight collaboration between the two schools has enabled students to develop interesting textile and fashion projects by combining creative design with materials research. The most successful example of CHEMARTS is the long-term development of Ioncell-F, a new technology to produce cellulosic fibers with excellent mechanical and haptic properties. Raw materials can be virgin pulp, paper, cardboard, or cotton waste, no toxic chemicals are employed in the process. In this project, the designers tested material properties by knitting, weaving, printing, and dyeing, and to produce prototypes to promote the technology The multidisciplinary Ioncell-F team received the Global Change Award in 2016 from the H&M Conscious Foundation for its cotton recycling process.

Creative Wear

CreativeWear is an Interreg MED project aimed at revitalizing the crisis ridden T&C sector through a new attention to creativity, personalized design, and artisan and small-scale production, for territorial value chains led by customer-driven business models.

The project seeks to recover and valorise the design heritage and "making" knowledge of Mediterranean cultures by bringing renewed creative energy to T&C clusters and industrial districts. It establishes a network of Creative Hubs that experiment different ways of supporting cooperation between creatives and enterprises. Pilot testing of these approaches are validating new, more

sustainable business models for cultural and creative industries that add value to T&C businesses in the Mediterranean. Cwear's Hubs are aggregators where the creatives community could find a physical place to meet and work but also the competences to push the engagement with companies. At the end of the testing phase the project evaluation underpinned the 3 main functions of the creative hubs:

- Matchmaking, to identify potential beneficiaries and find the best way to create hybrid innovation concepts through matchmaking of the creative and industrial inputs
- Adding Value: to deploye the Hub capacity to develop business models and creating services to support CCI/T&C business (e.g. training, prototyping, funding...) such as workshops, events or exhibitions and Bridging
- Bridging: a mending approach is required to connect the Hub's activity to the innovation ecosystem

FET-Art

The FET-Art project (FP7-ICT-2013-10)[40] stems from the "ICT & ART Connect" event that took place in Brussels in April 2012 under the aegis of the FET Unit and was comprised of a balanced partnership of organisations offering expertise in technology and art domains with important connections with technology and art practitioners in Europe and beyond.

The project has brought together art and technology communities across Europe in order to foster productive dialogue on art technology co-creation and collaborative work. The project had an all inclusive approach to collaboration, crossing traditional and visual arts, digital media, music, sound and design and equally across all technology and science practices. It was structured in a series of events organized differently, from hackathons to fast prototyping to ignite partnerships, while others focused on demonstrating successful art/tech projects while discussing the issues and challenging of the cooperation between the two domains.

Unless the short period of implementation, the project underlined some key issues for a fruitful startup of the cooperation: clear goals of the shared project, to agree in advance to the starting points, conditions, materials, approaches and context of the project.

WEAR Sustain

WEAR (Wearable technologists Engage with Artists for Responsible Innovation) Sustain[41] is a 2 year project funded by the European Commission Horizon 2020 research and innovation initiative to engage art, design and creative industries to work more closely with technology and engineering industries, to shift the development of the wearables and e-textile landscape towards a more sustainable and ethical approach. WEAR Sustain fosters cross-disciplinary, cross-sectoral collaboration through the co-design and co-development of ethical, critical and aesthetic wearable technologies and smart textiles.

The project focused on wearable technologies, and how these disruptive technologies open up new possibilities, notably for interdisciplinary collaborations between technology companies with artists/ designers with technologists.

At the core of the market for wearable technology is the amount of data that wearable technology companies are allowed to collect, in particular over their users' personal data. WEAR Sustain aims to contribute to the European Commission's sustainable strategy which include ethical employment of labour, workshops for embedding electronics ethically, sourcing locally made components, recycling and/or upcycling of both non-electronic and electronic parts, avoiding waste by fabricating made-to-measure wearables using CAM technology, economical application of new materials and so on.

The project, which ended few months ago has funded 22 teams in the first call for collaborative projects and 24 in the second call.

STArts INITIATIVE

Moreover, it is important to mention the STArts[42] initiative of the European Commission under the Horizon 2020 research and innovation programme which aim is to support collaborations between artists, scientists, engineers and, researchers. Structured in 4 pillars foreseen LIGHTHOUSE PILOTS, such as WEAR Sustain (a dedicated section is provided in the following pages) MindSpaces and our project Re-FREAM.

The best way to predict the future is to create it

Abraham Lincoln

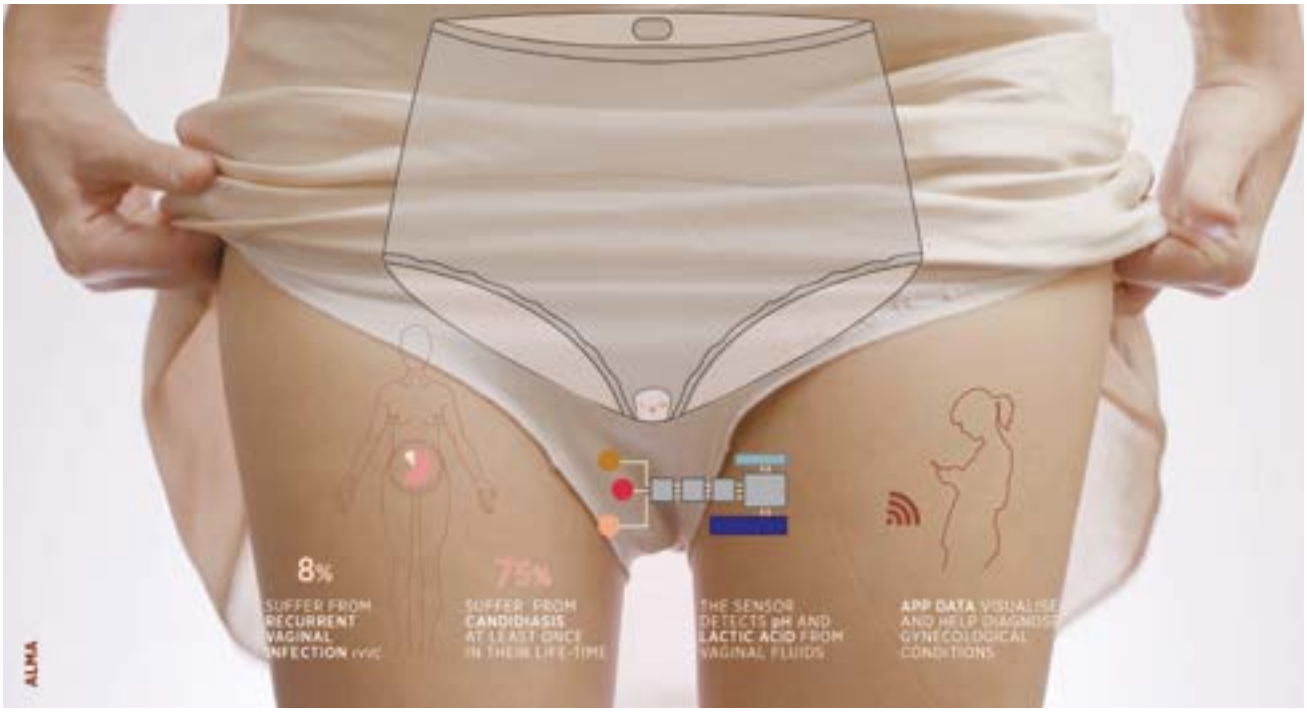
10 artists for 3 challenges

The results of the first call of ReFREAM

Photo by cottonbro - Pexels

Alma

Alma is a non-invasive wearable biosensor designed for the detection of vaginal infections. The project aims to develop a less conspicuous, wearable system that is low cost and reusable, capable of detecting pH from vaginal secretions and gather data that can be stored and used to reconstruct an individual's physiological profile over an extended period of time. The sensor's data will be interface with a mobile app, designed to monitor vaginal chemistry and generate educational awareness. ALMA is designed to empower women to become more familiar and confident with their own bodies. ALMA's vision is for women to become active patients who are more willing to seek professional healthcare advice, discuss their symptoms more openly and break the taboos that are still attached to gynaecological health. ALMA meets Flora is a workshop that explores how intimate female health is experienced by female in our society, inviting participants to co-design educational tools and methodologies to develop a new language that links access to technology and intimate self-care.



Giulia Tomasello

She is a designer committed to women's healthcare and its innovation, combining biotechnology and interactive wearables. Awarded by Re-FREAM, STARTS Prize and WORTH Partnership, for her projects Alma, Future Flora and Rethinking the Bra. Giulia offers a new deeper knowledge of women's wellbeing, developing innovative tools in the intersection between medical and social sciences. Coded Bodies is her teaching platform designed to learn basics of soft wearables and an exploration of biological textiles. Tomasello is currently a visiting lecturer at Politecnico di Milano. The last prize she won is the World Omosiroi Japanese Award, achieved this year for her multidisciplinary work.

Photo: Giulia Tomasello (C) akihico-mori

gitomasello.com

WeAReABle

'WeAReABle' project deals with the making process of customized fashion designs. It is based on 3D body scans and 3D parametric codes combined with multi-color 3D printing directly on fabric.
Goldstein considers the human body as a platform for innovation, focusing on smart textiles development. Ganit is working on examines the border between future and tradition, redrawing the boundaries between hand-made and 'machine-made.' By using parametric design software and changing parameters codes, the outcome consists of outfits that are fit-to-measure to the exact curves and figure according to unique body shape. The unique combination of hand made processes and cutting edge technology involves 3D Printing, dyeing yarns, hand weaving, embroidery techniques, 3D scanning and VR application. The final project presents unique 3D printed outfits produced using the pioneer techniques of multi-color 3D printing fabricated onto fabric using polyjet technology.

3D Textile printed with Stratasys J750. Photo: Michael Tzur

Ganit Goldstein

She is a fashion designer whose interest lies in the intersection between craft and technology predominantly working to incorporate 3D printing and scanning into 3D textiles. In her Masters Degree at the Royal Collage of Art in London, Goldstein specializing in Soft Systems and smart textiles. For her works, Ganit creates pioneer textile research-based methods, applying new techniques in innovative collections of garments and shoes. She believes in an interdisciplinary approach to design-mixing tradition and futuristic techniques. Goldstein's projects include collaborations with research development teams and great companies. With the use of cutting edge technology, in her collaboration with these technological companies Goldstein aims to push the boundaries of today's technology through innovation and creativity towards never-seen-before designs.

Photo: Ganit Goldstein (C) Winfried Reinhardt

www.ganitgoldstein.com

Fragments Garments

Based on this reusable and recombinable garment spare parts conception, two clothing collections have been developed in cooperation with European company partners Profactor in Linz (Austria), Aitex and Care Applications in Alcoi (Espagna) within the Re-Fream project. The first one «12cm2» explores the upcycling potential of seamless modular conception invented by Elisabeth Jayot and results in a collection of monochromatic garments using production textile waste to create patchwork combining numerous materials and textures. The second one called «Be Square» explores its customization potential. In order to lessen unsold and overstock, the collection offers to rely on a selection of white fabrics and transparent 3D printing filaments to propose not only on-demand production of clothing but also on-demand dyeing and finishing of garment spare parts and clothing fasteners using the sustainable and non-polluting micro-nebulization technology developed by Care Applications.

Photo: Elisabeth Jayot (C) Fabien Fourcaud, 2019

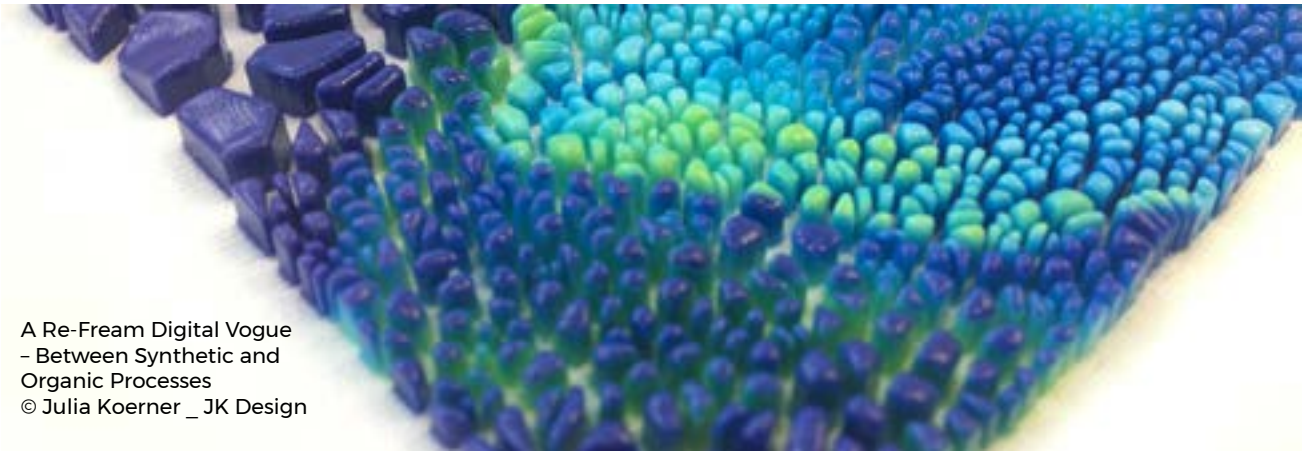
Elisabeth Jayot

Research & Design studio Fragments Garments has been founded in 2017 by French designer Elisabeth Jayot. Building synergies between traditional fashion design, prospective academic research and digital craftsmanship for a circular fashion future, Fragments Garments is a studio based in Paris offering alternative scenarios and processes for garment longevity and user involvement. Dedicated to reconciling sustainability with the pleasure of trends renewal, Fragments Garments creates seamless modular clothing which can be manually assembled or dismantled by the user without any technical skills or machine. Thanks to the plug and play attachment system the consumer can easily and quickly transform its own clothes according to changing trends, needs or size. Fragments Garments imagined a new fashion supply chain for the circular economy based on a local and on-demand production of seamless modular clothing using computer numerical controlled technologies.

www.fragmentsgarments.com

Digital Vogue - Between Organic and Synthetic Processes

Julia Koerner (JK Design GmbH) researches 3D to 2D to 3D relationships in 3D-Printed Fashion together with the technology partners Stratasys, Haratech, Profactor and consulting partner Department of Fashion & Technology, University of Art and Design Linz. The research focuses on digitally translating natural patterns into algorithms on the computer. It explores digital pattern design and multi-colour 3D printing on fabric, inspired by microscopic imagery of natural artefacts. This includes for example Sea Urchins, Corals and other living organisms found in the ocean. The digital designs are 3D printed in an innovative way, without any support material and directly on fabric in multicolour. The relationship between the colourful rigid geometries and the flexible fabric create enigmatic visual effects when the garment is in motion. In the initial research phase Julia Koerner and her team developed a series of 3D printed geometries with different colour patterns and effects and further explored colour gradients, image mapping and experimented with a variety of digital software. One of the challenges with consumer 3D-printed clothing is the practicality and comfort for the wearer. 3D printing on textiles holds the future in fashion due to its advanced wearability, as the 3D print is separated through a textile base layer and does not directly touch the skin. During the co-research phase with the technology partners Stratasys and Profactor a large variety of textile swatches of different weaves and dyes was tested and rigorous and benchmarked adhesion tests were developed to create a summary catalog. The implementation of 3D body scanning into the design process of garments was co-researched with the technology partner Haratech. Julia Koerner and her team thereafter developed computational design methods that automate the process from 3D body scan to final 2D file and to 3D print. Julia Koerner and her team are currently co-working on finalising a capsule collection to showcase the research.
The ultimate goal within Re-Fream is that the design workflows can be fully automated; from design to production leading to 'local production' and 'mass customisation'.



A Re-Fream Digital Vogue – Between Synthetic and Organic Processes
© Julia Koerner _ JK Design

Julia Körner

Julia Koerner is an award-winning Austrian designer working at the convergence of architecture, product and fashion design, specialised in 3D-printing. She is founder of JK Design GmbH and faculty member at UCLA.
Her recent collaborations include 3D-Printed Haute Couture and costumes for Hollywood blockbuster Black Panther.

www.juliakoerner.com

Photo: Julia Koerner (C) Ger Ger

Leather for vegetarians

During the process of the co-creation with Aitex, a documental investigation was started on products similar to “leather for vegetarian” and patent research to guarantee the state of innovation in the textile and cork industries. The tests conducted with various techniques (lamination, coupling, spray, fouling) have shown pros and cons of the state of the material at the beginning of the project.
From there, through laboratory practices, the performance of the material has been improved. The material, in all its variants (Synthetic leather, Suede) is lighter, more resistant to rubbing, wear, and cuts and remains more stable in washing at temperatures between 30-60 degrees. Its deposition of particles in several layers improves its mechanical performance, making it a suitable fabric for footwear and clothing. The pigment adheres better to the particles and allows a greater variety of colorations. The production process is faster because there is no need to extract moisture from the particles and stabilize them before mixing it with the bio-PU. By using Ecofinish technology in Re-Fream project, a waste product is valued giving a new life to something that in its natural state, it is almost useless, achieving a typical worn effect of denim. With Care applications, a third development line was opened designing a new cork finish, applied directly to the garment.
Thanks to this eco-friendly system, it is possible to achieve new effects on the surface of ready-made garments by applying chemical products or dyestuffs directly inside the washing machine. The system micronizes the water droplets and the cork particles until it achieves a misty effect, thereby allowing its controlled diffusion on the material. Several tests were done in order to create the perfect composition and moisture, now a day we are working on colors with cork particles.

Photo: Fabio Molinas

Lebiù by Fabio Molinas

Lèbiu (lightness in Sardinian language) is an Italian Design company based on the island of Sardinia. We provide eco-fabrics and vegan leather for Design and fashion sectors, introducing the new applications of cork waste in a more ecological way thanks to the bio-based additives used and a high percentage of cork residue.

www.fabiomolinas.com

Marinero

Inspired by the contrast of the sea and plastic pollution. Marinero is the first project of Studio Adaptive Skins. The focus of Marinero is to create an architectural blueprint that transforms organically over the course of time due to different weather conditions. The blueprint is one woven square that forms the base of diverse variations. All produced Marinero fabrics are used (no waste). Because the finishing is already incorporated within the woven pattern, the materials take its shape by the various conditions rather than using traditional cutting and tailoring techniques. The materials used to create yarns for the woven square will be divided into categories. The main categories are: 1 Adaptive Archi-Filament A+B (designed yarn by Jef Montes & produced in collaboration with partners: Aitex Alcoy and Wood K Plus in Linz), 2. rPET (recycled plastic waste from the sea) 3. PLA (Bioplastic); 4. Seacell silk yarns that are dyed with algae pigment. All these produced yarns need to be transformed into usable threads that can be used for the TextileLab Tilburg machines. The vision is to design a new kind of production system resulting into adaptive garments that grow with us individually. The weavings have a warp of monofilament and a weft of integrated variable threads. The combination of these threads (horizontal versus vertical) cause friction and result into dynamic shapes during different meteorological conditions such as: rain, heavy wind or drought. Next to the weavings we will also experiment with knitting techniques. All the 36 Marinero garments will be placed on rooftop installations in: Linz, st Gallen, Arnhem and Alcoy.

Jef Montes

Studio Adaptive Skins was founded in 2018 by designer Jef Montes. Adaptive skins is a textile architecture studio based in Arnhem with a strong emphasis on responsive materials. A new approach on creating shape within the materials rather than cutting patterns out of 2D fabric. The materials are applied on the human skin but also connected to the structure of a building and interior. Responsive to the human and its surrounding the textiles improve the function and experience of: body, light, energy, areas, acoustics and climate.

studioadaptiveskins.com

Photo: Jef Montes (C) TextielMuseum-TextielLab

Jessica Smarsch

She is a designer with a background in textile design. After receiving a Masters in Social Design from the Design Academy Eindhoven in 2015, she began focusing her work towards health and well-being. With a particular interest in health as a matter of the body and the mind, she began to narrow her work in 2017 towards stroke rehabilitation and has been working in this domain since, developing a sensor garment and app for home rehabilitation.

jessicasmarsch.com

Image: Jessica Smarsch (C)LISA KLAPPE PHOTOGRAPHY (2015).

Constructing Connectivity

In 2019, Jessica Smarsch was chosen as one of ten artists to collaborate with scientists and technologists through the Re-Fream grant. Fraunhofer IZM in Berlin has been her main technology partner, and she has worked with them to develop TexPCBs for the measurement of muscle activity within her stroke rehabilitation system. The TexPCB product and technique, developed by Fraunhofer, laminates conductive fabric between thermoplastic material and can be applied to a wide range of applications. Taking further design steps, they have worked to integrate the technique into an aesthetically considered, custom knit garment that uses performance yarns to enhance the integration of the TexPCBs, provide comfort & compression, and defend against bacteria. Smarsch has also worked with Re-Fream partner Stratasys to 3D print on the garment to create an aesthetic and functional connection to the processing module. The goal throughout the project has been to create something that works, but that is also elegant and even revealing some of the beautiful aspects of the technology.

Cooking New Materials

The project 'Cooking New Materials' is an independently developed technique which aims to process bio-waste into a soft but yet robust leather-like material. The seemingly useless food wastes will reborn with a second life. The concept was inspired by observing the life of conventional textile and they find out that there are great potentials by using bio-wastes and create a brand-new biodegradable new material. The team utilise banana and orange peel or soy-milk residues to combine with a natural binding agent as the substrate. The resulting composite is fully biodegradable and can be easily reused after the re-cooking process. It is a 100% bio-degradable, zero waste natural product. Moreover, the bio-material provides similar toughness, durability and water resistance as normal leather material, especially it conserves fruitiness smell, refined texture and feels very good on touch. The team process the material with different techniques such as dyeing, weaving, laser cutting, laser printing and different pattern moulding. The vision is to establish a complete and viable closed-cycle ecosystem based on their Bio-material. In this ecosystem, the Bio-material conveys their sustainable design concepts and though a highly interactive product system, the team can deliver and express our goal of environmental protection. Additionally, their products are not merely preserving but restoring the environment. Due to the nature of the product, the team ease the burden of urban waste management as they strictly follow a 'low carbon' guideline in their manufacturing process. Right now, the materials can be applied to different user scenarios.

Youyang Song

Youyang Song, a textile designer based in Berlin. She is always passionate about innovating game-changing technologies and ideas in the new material industry. She devotes herself in developing new biodegradable material, innovating and improving new material production as well as designing new material around a sustainable concept.

www.youyangsong.com

Image: Youyang Song (C) Youyang Song

Lovewear

The project developed with the support of Fraunhofer, it's a smart underwear that helps people of all abilities to self-explore and enhance their own intimacy and sexuality. Sexuality is a human right accordingly to the United Nations and the Convention on the Rights of Persons with Disabilities, but unfortunately it is still a big taboo especially for people with disabilities. Lovewear wants to empower the wearer through a tactile experience achieved by Inflatable inserts, activated within the underwear linen, through the interaction with a connected 'console' pillow. The wearer can hug, cuddle, caress, press this interface as a surrogate for the human contact or just explore the body surface facilitating gestures. The design has been developed with the support of a sexologist and with the participation of volunteers that opened up and shared their experience, first through a questionnaire and in a second phase with a focus group, which helped us to better define the user experience. They focused on the manufacturing with high frequency welding of patterns to generate stimuli and further interactions (reach sensible points, generate pressure, increase garment fit). Patterns are divided in sectors that inflate and deflate independently to mimic the tactile experience; the inflation sequence contribute to generate a variety of effects; the pump and valve work simultaneously to guaranty a continuous experience without interruptions or scattered sensation. The design have been studied to accommodate a quantity of electronics and actuators. The design of the underwear consists of distinct elements that are detachable for washing and maintenance purposes; the overall design is modular in line with Eco-design principles to ease maintenance, repairs and replacement of failed elements.

Witsense team

Witsense is a start-up whose members are based between Milan and Dubai. Their aim is the development and production of innovative products and services of high technological value: sensory products and instruments, design elements that can improve life conditions, favoring social inclusion through the promotion of independence, behavioral competences and learning. In their perspective, technology should be embedded in everyday life, into objects that are improving little aspects of a daily routine.

www.witsense.design

Photo: Witsense Team

Re-think manufacturing

The project is aimed at developing a seam technology that fits in this overall initiative, based on 3D printing. 3D printed seams are not only suited to simplify the overall manufacturing process by allowing the elimination of production steps like seam taping, they also provide inherent benefits compared to traditional seaming, such as being waterproof. While 3D printed seams bear huge potential in the area of functional clothing, Yokai Studios puts an emphasis on the overall manufacturing system, which consists of individual modules, ideally suited for a micro-factory setup. Running multiple micro-factories in different locations enables the increase of local added value as a more sustainable production and distribution by eliminating then superfluous

Image: Michael Wieser and Viktor Weichselbaumer (Yokai Team) (C) Mario Riener

Yokai Studios

Yokai Studios initially started as a research project, aimed at bringing back clothing production to Europe by employing modern technology. Yokai Studios has turned into a company that produces clothes and is dedicated to creating a robot-based automated manufacturing system. The manufacturing system will provide a competitive advantage in terms of cost and quality, compared to traditional manufacturing methods. Using 3D measurements, design and pattern construction methods, customized clothes can be created with little to no extra efforts.

www.yokai-studios.com

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