

## ARTICLE

## Scientific method and creative process for wearable technologies from invention to innovation

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The aim of the paper is demonstrating how in the contemporary scene the boundaries between scientific method and creative process are increasingly blurred finding innovation as the point of intersection of this discursive separation. The analysis identifies the object of investigation in the emergent field of fashion wearables. Indeed, the introduction of digital tools has had a significant impact on the fashion system, and wearable technologies represent the result of a new systemic interaction among diverse approaches belonging to different sectors. In this context, our purpose is to identify the moment when invention, seen as technological progress, becomes innovation, integrating and affecting people's lives. To this end, the paper is firstly aimed in analyzing through case studies the different methods to design innovative fashion products. Both technology driven innovation and design driven innovation based methodologies are examined. The two strategies are compared and described in terms of phases, actors involved and validation of the obtained results, underlining the crucial stages of the process: the definition of the target and the scenario and the phase of product testing. This involves both traditional methods of data analysis for the technological functioning, based on numerically quantifiable parameters, and experimental verification based on the object-final user relationship. This test aims at "measuring" the effectiveness of the products in terms of comfort, usability, aesthetics and interaction. It is this methodological transdisciplinary practice that carries appreciable results concerning innovation. This approach leads to an emphasis of the designer's cross role and it represents an opportunity for the academic research as well as for the market.

Keywords: fashion wearables; scientific method; creative approach; technology; innovation.

### Fashion design: between creative and scientific method

*"You can't connect the dots looking forward; you can only connect them looking backwards. So, you have to trust that the dots will somehow connect in your future". Steve Jobs (Jackson 2011)*

In 2005, during his speech at Stanford University, Steve Jobs talks about the importance of connecting dots. The idea behind the concept is that, as much as we try to plan our lives ahead in advance, there's always something that's completely unpredictable but also it comes to light the importance of the past as a mirror for the future.

Starting from this quote, both the scientific method and the creative process were considered as pure methods, symbolizing the past and the idea of looking backwards; then, their evolution, under the shape of different dots, is represented: a fragmented reality characterized by the coexistence of a plurality in the field of applied research; the last step stands for the goal of such research: a system based on interaction, where the dots are connected one to the other, with the aim of creating a cross-exchange among different fields. That is how *the dots will somehow connect in the future* (Figure 1).

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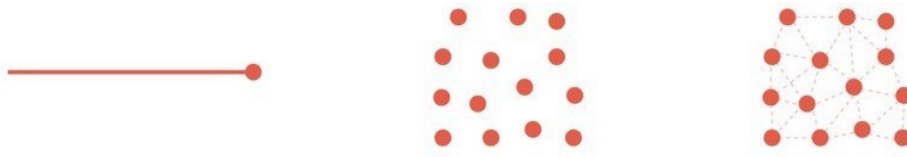


Figure 1

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### The scientific method

The scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge (Goldhaber and Nieto 2010) based on an empirical or measurable evidence subject. The process is a fixed sequence of steps resulting from the formulation of a question that comes from observation. Even though the scientific community and philosophers of science have developed different methods for scientific inquiry, four essential common elements can be identified: *characterization*, intended as observation, definition and measurements of the subject of research; *hypotheses*, resulting from the observations and measurements of the subject; *deductive theoretical predictions*; and *experiments* to test hypothesis and predictions. Crawford and Stucki (1990) offer a pragmatic scheme of the four points above as a guideline for proceeding:

- Define a question;
- Gather information and resources, observing;
- Form an explanatory hypothesis;
- Test the hypothesis by performing an experiment and collecting data in a reproducible manner;
- Analyze the data;
- Interpret the data and draw conclusions that serve as a starting point for new hypothesis;
- Publish results;
- Retest (usually done by other scientists).

The iterative cycle, inherent in this step-by-step method, goes from point 3 to 6 and eventually goes back to 3 again. The scientific method is aimed at an objective, reliable and verifiable knowledge of reality obtained through the collection of empirical data under hypotheses and theories, followed by a rigorous mathematical analysis of these data by associating the *sensible experiences* to the *necessary demonstrations* (Cromer 1977).

### The creative process

If science, at its core, is a method of practical logic that tests hypotheses against experience (Greer 2015) the creative process, however, is nothing more than a problem-solving process that creates original and new solutions to the existing ones (Cavallin 2015). This is based on comparative logic processes, often coming alongside the intuition of the creative talent who, according to the Theory of Attitude (Von Neuman and Morganstern 1944), can choose using rationality and objective reasoning and is led to decide through algebraic processing of the collected information.

The scientific method is almost perfect for understanding physical aspects, but it is a radically limited viewfinder in its inability to offer values, morals, and meanings that are at the center of our lives (Smith 2001). This, instead,

is the focus of the creative process, as it is essentially based on experiences. In detail, five steps shape the creative process:

- *Preparation*. The creative figure is immersed in an environment with the aim to absorb as much information as possible;
- *Incubation*. All the information gathered during the first stage are 're-managed' in the mind of the artist. This is an open-ended phase;
- *Insight or illumination* is the 'eureka' moment, the intuition that combines the collected and incubated information;
- *Evaluation*. It consists of self-criticism and a qualitative reflection;
- *Elaboration or implementation* define the last step. This consists in testing and working on the idea.

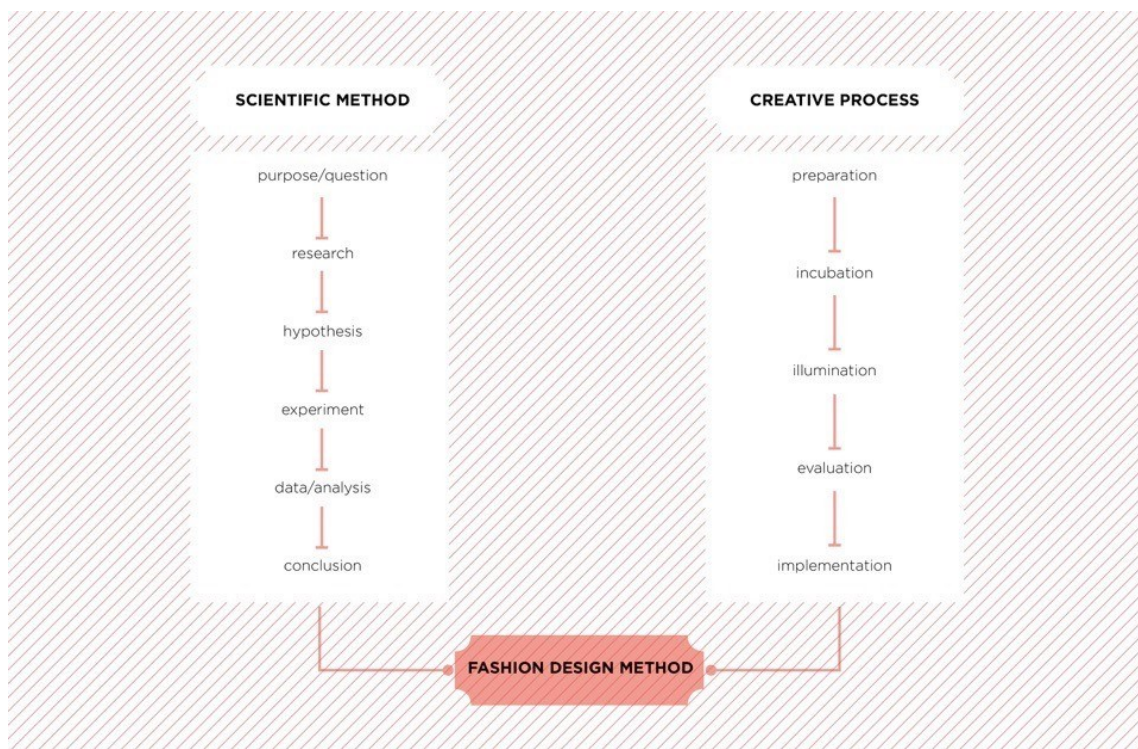


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### The fashion design method

The scientific method and the creative process are deeply different, but it is possible to identify their intersection in the role of the *experience*. One, objective, is based on scientific tests and the other is based on inductive reasoning founded on experience, a daily experience that demonstrates how the human being is led to make decisions moved by the stimulation of emotional values rather than objective ones (Kahneman and Tversky 1979).

Design thinking is an expanded scientific method, including observation and the discovery of human behaviors, the emotions behind those behaviors, using those data to create solutions to complex business problems. It can work well in combination with the scientific method. While the scientific method excels in understanding objective and quantitative data, design thinking offers a way to collect and understand subjective and qualitative



ones, such as customers' desires, needs, as well as their personal histories and experiences (Ferreira et al 2015). Fashion design is halfway between these two methods, based on a methodology that combines scientific and analytical rigor, with creative and practical thinking skills (Stenberg 1996).

According to Feyerabend (2010), the belief that only a single methodology can produce scientific progress is absurd (Lloyd 1997), and, according to the necessity for teamwork in operating multimillion-dollar machines, has created dynamic *trading zones*, where instrument makers, theorists, and experimentalists meet, share knowledge (Galison 1997). The fashion design process is made up by different phases, both belonging to the scientific method (such as the *problem definition* and the *market research*) as well as to the creative one. In detail, the first step consists in the definition of the problem. This is followed by a background research, in terms of user needs and desires, a market research for products and competitors, trends and forecasts, and a materials research; specification of requirements, a phase where the creative process merges with the scientific method. This latter is made up of a brainstorming moment, an idea evaluation, a solutions selection, a concept and materials definition, a sketches and prototype development; the last phase consists in the product implementation.

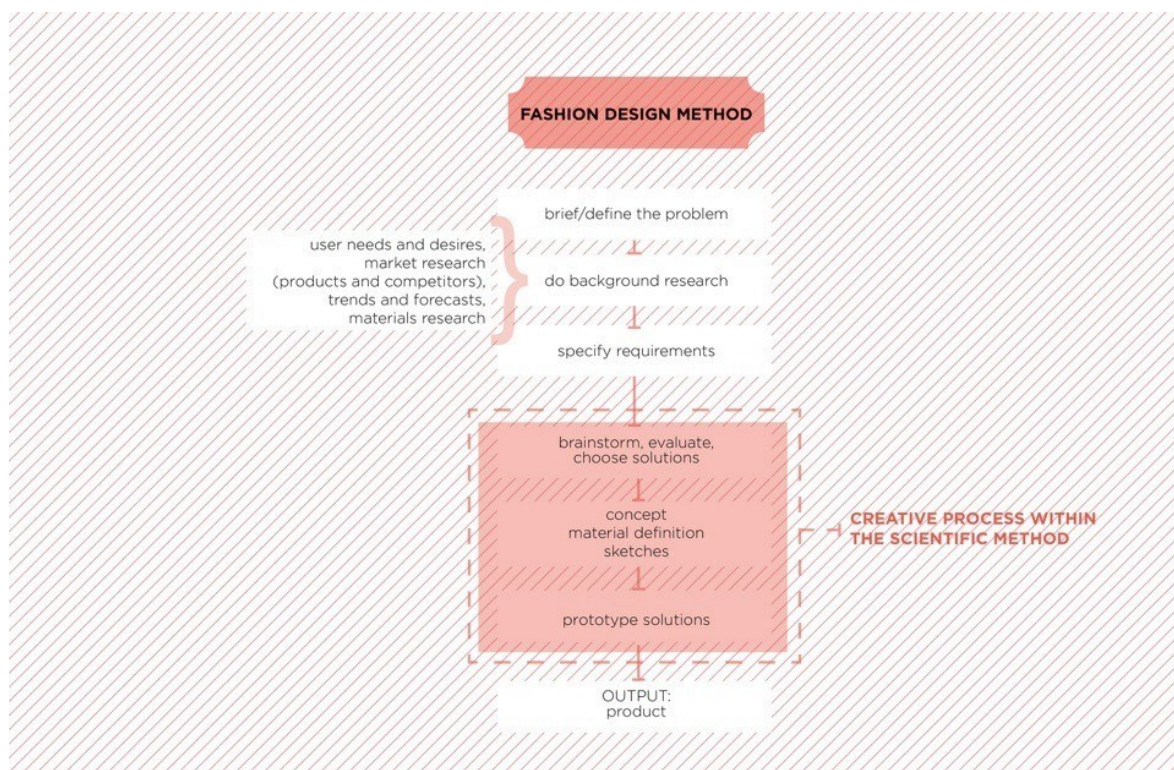


Figure 3

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### Wearable technologies as point of intersection between fashion processes and digital technologies

2013 was identified as the year of 'wearable technologies', where the first significant attempts towards the grafting of digital technology with fashion – in particular the field of accessory - arose. Google Glasses had just been launched, the embryonic prototype of smartbands were hitting the market and Harry Strassen was giving the opening presentation to the Wearable Technologies Conference, showing a smartphone and assessing that all

its functions could have been integrated into everyday objects (Wearable Technologies Conference 2013). Harry Strassen ended the speech leaving some crucial questions intentionally open. These queries dealt with the main opportunities and challenges for wearables, such as the possibility for these products to reach the mass market, of significantly impact consumers' lives in the same way as during the mobile revolution, to achieve functional and aesthetic autonomy, independently from smartphones.

Today, many of these questions have found an answer. Wearable technologies have finally hit the mass market and are the result of a combination of tools and methods belonging to distinct sectors and disciplines, involving issues concerning both the technical operation and the working principles of the device as well as the relation with the users, their bodies, habits and gestures.

### **The Market of Fashion Wearables**

As industrial fashion designers, our research started from a preliminary investigation of the market production of wearables by fashion companies. Except for the innovations in the fields of production, communication and advertisement, what we discovered was that luxury and fashion brands have often shown certain difficulties and even suspiciousness towards the adoption of embedded digital technologies. Even if several companies are persisting in this attitude, different brands and designers have now come to realize the potentials of this cross-fertilization, overcoming the former boundary between the two. It is frequently the case of artistic experimentations, products able to light up, change color, generate incredibly complex forms and exploit the possibilities offered by new production methods.

For example, artist Iris Van Herpen mix craftsmanship with innovative techniques and materials creating a unique stylistic expression even without addressing real customers. An example is drawn from 2016 New York Fashion Week. Lumina collection by Chromat (2016), a fashion label formed by Becca McCharen, explores technological garments that interact with body's performances as simply as a web page fits into a computer screen. After collaborating with Intel for a smart sport underwear line, where products could detect body warmth and consecutively adjust the surrounding temperature, Becca McCharen launched a new collection inspired by natural shapes and the conceptual art of Robert Irwin. Thanks to the built-in technology - the Intel Curie module and StretchSense motion capture sensors - these clothing can light up in the movements of the wearer. These are currently only experimental projects, far from real contexts and not really pledged in answering actual customers' needs (Park 2016).

So far, fashion juggernauts have not truly come closer to technology. Particularly, wearables do not considerably stand out, they are still quite rare and, in most of the cases, they show the superficial approach of merely wearing existing technology. Quoting Charles Bukowski (2005): *style matters*. Following this logic, in 2014 Google managed to foster the adoption of Google Glasses by the prestigious Fashion House of Diane Von Furstenberg (Sedghi 2014). The brand agreed to provide models with that piece of tech for a catwalk at that year's fashion show in the attempt of getting closer to their customers by giving an immersive experience of the collection from the model's point of view. Unfortunately, this collaboration resulted in a version of the Glass that did not show any different feature from the original model other than the possibility of changing the glasses' lens and frame color. The project performed poorly on the market and was withdrawn in 2015 (Bilton 2015). Similar is the case of iWatch by Hermes, celebrating the partnership between the tech giant Apple and French luxury maison (Huen 2015). The collaboration had good premises in improving the initial product features, but ultimately the only difference appeared to be the watchstrap, despite being it branded and made in high quality leather.

The spread of a new trend within the intersection of fashion and technology emerges from these collaborations. Fashion has always widely resorted to using technology as a tool for self-promotion, as it is for a large amount of fashion blogs, live fashion show and e-commerce platforms. On the other hand, whereas in the past technology used to determine fashion trends, now roles seem inverted. Tech devices became a tool for individual expression and now follow the rhythm and dynamics of the fashion industry. A clear example of this logic can be testified by the constant growth of iPhone-related incomes after every new release. Current complex technology makes use of fashion as a mean of self-advertisement, to get closer to the public, to appear more human, desirable and approachable. Apple's team includes today top managers coming from Burberry and YSL, proving that fashion industries have the power to reach mass customers regardless the target (Kansara and Pike 2015).

A lot of fashion apps are still being developed by tech teams, which are not aware of the logic of the fashion industry and are still not including designers from this field. As a matter of fact, fashion is one of the world's largest markets and it's highly challenging and demanding; for instance, an e-commerce platform that is poor in graphics and aesthetics will not survive. Lastly, the interconnection between fashion and technology still faces difficulties such as the speed of production. A fashion product is considerably faster in its making, as this is not the case for science and technology timelines whose speed of development can take years or even decades. Fashion industry had never had to relate to a R&D department that sits years behind (Parkes 2014).

### **Invention and innovation in Fashion Design**

The results we obtained from the market investigation showed a significant deficiency on the side of the integration of technology into fashion products, revealing flaws that also affect the process. To reach a satisfying integration of the different components and to overcome the divergences and synthesize the different approaches, a review both of the design methodology and the required competences was needed. This renewed methodology should connect and combine the process of design to IT ones, dwindling the boundaries between creativity and scientific method.

Fashion Tech is the crossing point of fashion, industrial design and IT: aesthetics, comfort, the centrality of the role of the user and usability are applied to the sector of electronics and digital technologies, where the inventions and the progress in terms of multi-functionality and performances, dimensions and cost, represent the driving force. The complexity of languages and the heterogeneity of the actors gravitating around the world of fashion technology entails the necessity of creating a code being able to better connect the various areas involved to create synergies among the processes while facilitating the transition from invention to innovation through design.

The difference between invention and innovation is subtle yet important. The invention, generated in the scientific field, creates a set of possibilities that are applicable in the consumer market. Therefore 'innovation' is an applied invention, as it can produce an impact on the market; invention is about creating something new, while innovation introduces the concept of 'use' of an idea or of a method; an invention is often a 'thing', while an innovation is an invention that causes changes in the behaviors or in the interactions (Mirande and Henchoz 2014). It is within the field of fashion wearables that we recognize the moment in which invention turns into innovation.

The field of fashion design, product design and the one of IT are made up by different causes and the intersecting point among them is the design of fashion wearable technologies. Wearable technologies, today, represent a real opportunity for the market to generate new behaviors, interactions and methods, to be innovative thanks to the inventive component typical of the world of engineering and the value-driven nature of fashion design.

## Applied research

The main objective of our research was to define a transdisciplinary and generative methodology able to combine the processes of fashion design and the engineering. This would satisfy in a more general way the market request with more versatile professionals able to control an emerging topic (i.e. wearable technologies), to develop competences to design innovative products. Such products are innovative for their ability to improve the experience of the user and at the same time to be effective on the side of performances and aesthetics. Within the field of fashion technology, the two complementary methods are currently applied alternately. This result is a lack of integration and dialogue between the two fields. This has significant impact on the relationship between form and function of a product, and it generates a negative or not perceived user experience. Today, creating experiences is crucial for the success of the product on the market.

The methodology we used belonged to the field of applied research, conducted through an analysis of case studies and participant observation during pilot workshops. With this aim, we tested the application of three different approaches (Vacca and Warshavski 2016):

- A *multidisciplinary approach* where the different actors work in coordination through a cumulative methodology (which is the sum of every single method) that can merge the experiences of each participant;
- An *interdisciplinary approach* based on a deeper collaboration among the actors, generating a hybrid methodology;
- A *trans-disciplinary approach* where the participants work together and share knowledge and processes, in a continuous exchange along the steps, therefore creating a generative methodology.

For the three methodologies, we then defined three different parameters to evaluate the success of the experience (Figure 4):

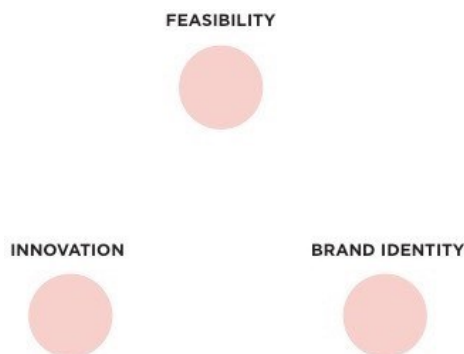


Figure 4

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- The technical and *technological feasibility* in terms of performances, price, industrial development;
- The *innovation degree* here intended as the capability to generate new contents;
- The *brand identity* for the coherence to the aesthetics of the client company.

The three experimental pilot workshops are described below.

## WS #1

The first workshop involved a fashion brand as a client, a product and interaction expert as a support and 20 young fashion designers who were asked to develop the project. The brief given by the company consisted in integrating innovative technology in the field of eyewear.

The process was conducted following the traditional phases of fashion design methodology: brief launch by the company, research around users' needs, market research on existent fashion products and technological components, so to define and develop the concept.

The main results we obtained from this workshop concerned the preliminary phases of the design process, such as the idea to start from a specific target or environment with well-defined features in order to then extend the use of the product to a wider target. Moreover, a new step was added into the fashion design process: the phase of the scenario definition, describing not only a need but a specific and future context of use for the product. The brand appreciated the outcomes in terms of innovation but did not consider the issues related to the technical aspects of the products in terms of feasibility since the designers didn't have proper skills in digital technologies. (Figure 5).

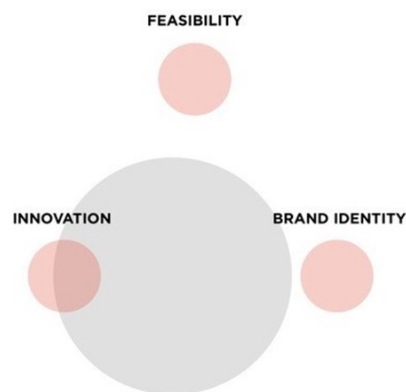


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## WS #2

Starting from the experience of the first workshop, where the major issue arose was related to a lack in the technological skills, we decided to include also a tech company and a technology expert in the second workshop, together with a fashion company and smart textiles expert, to support the young fashion designers in the projects' development.

The goal of this second workshop was to develop a smart underwear collection, according to the aesthetics and the codes of the fashion company. We decided to include the phase of scenario definition in the methodology, since we identified it as crucial in the previous workshop, asking designers to develop a storyboard to better understand, define and describe the possible experiences they wanted to address and that they identified as future trends in the wearable technology market.

The different actors were involved in all the phases of the methodology, but the reviews were alternated, meaning the project was checked by many actors at the same time. The consequences of including a technological expert and a company generated chaos along the steps because young designers had to alternate



different approaches without integrating them. Moreover, the designers' role along the process was unclear: they were asked to solve problems related to technological issues even though they lacked skills in that specific field, instead of focusing only on design aspects. Therefore, what became clear was that the field of fashion technology does not need professionals that are able to solve the issues of both the fashion and the technological field, but rather professionals that can adapt themselves and communicate with the other team's professionals while sharing knowledge and methodologies along the process.

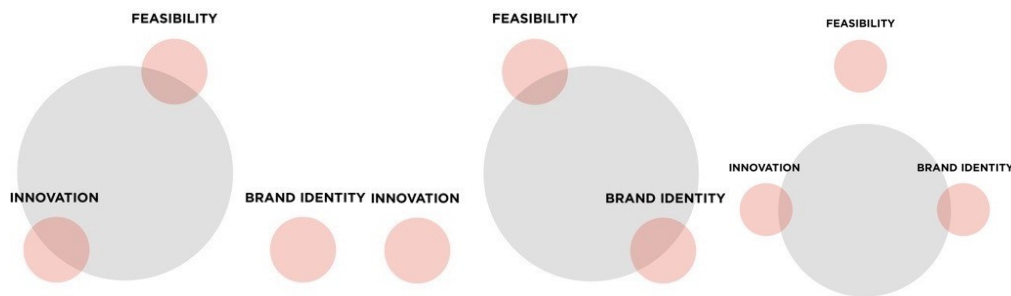


Figure 6, Figure 7, Figure 8  
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The result of different outputs as well as the feedback from the companies showed the difficulty of satisfying all the three parameters. The high grade of integration of fashion and technology with good results in terms of feasibility and innovation leads to an aesthetics that reflects the function of the product, clashing with the image the brand intended to deliver (Figure 6). Indeed, when the traditional image of the brand is satisfied, and it is technically implementable, there is not a strong impact on innovation (Figure 7). The latter case is very close to first pilot workshop; therefore, the image of the brand is well respected, and the project describes innovative scenarios, but then technologies are still too experimental - immature or expensive - for an industrial production (Figure 8).

### WS #3

From the results of the two experimental workshops, in combination with the analysis of case studies taken from the market, we can assess that today technology companies and startup companies are successful examples in the field of wearable technologies. In fact, technology companies' aesthetics is already linked to technological components, while startups' brand identity is associated to an aesthetic that can include and be coherent to the functionality brought by technology since their establishment. For the third workshop we stepped back and decided to act independently from the companies. We launched a pilot brief to analyze possible shared methodologies where designers and technology experts had to share the design process from the concept to the communication. The workshop was conducted by three groups. Each group was composed of a designer and an engineer that had to design a smart bag collection with embedded technology working together along every single step. Even though the brief was the same for all the participants the outputs were completely different, not only in terms of aesthetics but also in terms of functions and interactions.

When it comes to the products conceived, one of the main results consisted in the successful integration between technology and fashion. Fashion becomes a mean to communicate what technology does and vice versa, so the problem of form and function that we explained in the first part of the paper was solved. Regarding the process, the two actors shared the same methodology along every single step: modifying, adjusting and implementing it. The groups decided to include users to collect information and to informally test the project from the idea to the prototype even though they were not specifically asked to. In this last case both feasibility and innovation were fully satisfied in all the projects (Figure 9).

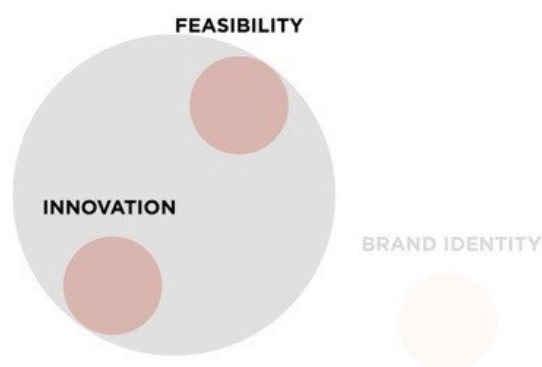


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### Fashion wearable design method

The experiments mentioned above led us to develop and trace a hybrid methodology that merges some elements of the fashion design method to some from the engineering one. Fashion wearable design method, as we called it, is a mix of the two different approaches, starting from the definition of the problem, going through a background research that explores both the user needs and desires, the fashion market research, trends and innovative and existent technologies ready for the industrial production. This new methodology is well explained as scheme in Figure 10.

After the requirements definition, the creative part takes place. This is the phase of brainstorming that is followed by the following step of the definition of a specific and future scenario. Here the product is the protagonist, becoming the point of connection among the user, the environment and other objects. This phase leads to the definition of the concept and the implementation of the product. To test the user interaction through experience and *emotional* measurement of the relationship between the user and the product, a qualitative check was added to the quantitative check that is typical of the engineering method.

All these steps have to be managed by both designers and technologists to achieve successful output, merging and contaminating their skills. This paper proposes alternative prospects for the traditional fashion design process. The methodological proposal is a starting point for optimizing the design of wearable technologies. This would benefit not only the academic sector, but also the market, as it can promote and foster interdisciplinary knowledge.

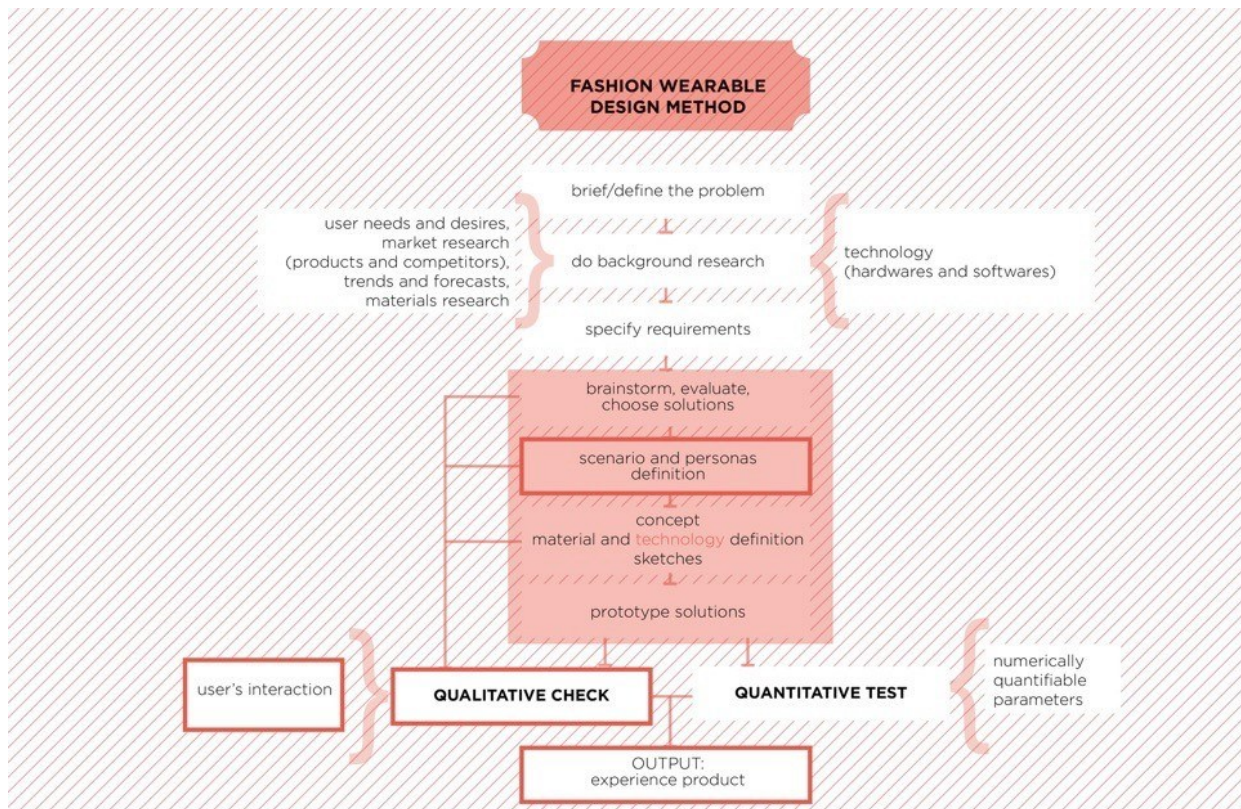


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