

ADVANCEMENTS IN DESIGN RESEARCH

11 PhD theses on Design as we do in POLIMI



edited by Lucia Rampino and Ilaria Mariani



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DESIGN INTERNATIONAL

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FashionTech: Interaction Across Boundaries.

Integration practices for design-enhanced user experiences

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Abstract

The purpose of this dissertation is to identify the tools that are necessary to streamline the design process of fashion products with embedded technology.

This study endeavours first and foremost to summarise and provide a critical analysis of the state of the art in fashion innovation by referring to both the relevant contemporary literature and market analysis documentation. It especially focuses on FashionTech, a sector which derives from the interaction between fashion and digital technology, and it explores the role played by new technologies in creating interactive experiences for consumers.

This work's theoretical research stresses the great opportunities made available by new digital technologies embedded in products, especially as far as interaction and the generation of consumer experiences are concerned, as well as the widespread interest that pervades markets; on the other hand, it also emphasises their limitations and the open challenges deriving from methodological deficiencies.

By using the identified limitations as a premise, the study then introduces a number of methodological tests on the designing of fashion products with embedded technology, which have been carried out both in academic circles and on the market.

The outcome of these tests is presented as a methodological proposal and as a tool for integration-based design. This approach allows the study to highlight the need to train professionals capable of playing a cross-cutting role in the integration process between the disciplines and the actors involved.

A Border Line Condition

Modern Wearable Technologies

Although enormous progress has been made in this sector and the boundary between fashion and technology is increasingly less defined, the FashionTech sector, and especially the wearable technologies subset, is facing an important challenge in social, cultural, linguistic and methodological terms.

One of the roles which fashion has always played is the transformation of technological progress such as smart fabrics or new materials into products which are wearable and appealing to consumers; indeed, fashion and accessories were among the first vectors to bring technology into contact with the body's physical dimension (Fortunati *et al.*, 2003), and nowadays they are essentially a physical and aesthetic extension of the body itself.

The fashion system is now fully permeated by technological advancement, products with embedded technology or, in more general terms, by FashionTech and its forward-looking vitality.

'Wearables are one of the newest frontiers in the tech space', 'wearable technology like the Fitbit is becoming increasingly popular and that trend is only going to increase as the technology improves' (Hastreiter, 2017), 'technological innovation, or FashionTech, is a strategic issue for the fashion industry's future, and the arrival of technology in this universe continues to shake up codes and practices' (Premierevision.com, 2018), are only some of the statements that have been made regarding the trends shown by the wearable technology market.

While global sales of wearable products with embedded technology are on the rise, they have not yet matched expectations. In 2017 the overall percentage of sold devices, including wristbands and watches, reached 7.5% of the mobile phone market, with a 7.3% increase as opposed to the previous year. By comparison, Statista has estimated that the average smartphone sales increase between 2005 and 2015 was about 35.6%, and for many years they even reached 60% before they settled on the present, relatively stable sales trend.

It is nonetheless important to clarify that contemporary trends concerning all products of this kind are extremely unstable. Although smart bands used to be top-selling items, in 2017 their sales dropped dramatically; the analysis carried out by Matt Turk (2018) showed that Jawbone had been shut down, while Fitbit and GoPro's share price has noticeably fallen since 2015 and 2016.

Some doubts also persist in other related sectors: the Consumer Electronic Show 2018 (CES) did not show any increase with regards to the sale of wear-

able technology on the mass market. As for watches, market demand is mainly met by the electronics industry, but even the soundest companies (i.e. Samsung, LG, Huawei, etc.) are seemingly following traditional production patterns.

Market analysis has moreover shown that business models based on the B2C sale of fashion products with embedded technology often struggle to be sustainable. Between 2017 and 2018 start-up companies active within the sector such as SolePower, Vinaya, Ringy and Wisewear announced their withdrawal from the market (Fashioner.com, 2018).

Market Limitations and Design Opportunities

‘Unstable’, ‘energy-consuming’ and ‘erratic’ are some of the definitions provided by many fashion company executives when asked to describe succinctly the sector in which they operate (The State of Fashion, 2017). Their perception is reflected in the sales data for 2017, which for instance showed a dramatic drop for many smart band producers. Unlike sales of devices such as smartphones, the slow growth of the global sales of fashion products with embedded technology poses limitations on more than one level.

The present analysis seems to indicate that the limitations associated with fashion-related technology products aimed at the consumer market are mainly caused by the business models adopted by fashion companies, which struggle to manage the various process stages.

With the rare exception of Fitbit, Fossil and Apple Watch, FashionTech products presently on the market have not recorded satisfactory sales levels. The UXS Technology Planning Report: Wearables compiled by Strategy Analytics’ User Experience Strategies (UXS) department explored consumer needs, behaviour and expectations with regards to wearable devices and remarked that hardware design is one of wearable technology’s most complex aspects, which places a rather burdensome constraint on the whole project. Indeed, wearables are required to meet specifications such as size, energy consumption, safety, interaction performance, and they are expected to be affordable, comfortable, non-invasive, and in many cases even fashionable. Greater functionality and power inevitably entails greater size.

One of these products’ main limitations is power supply, an aspect of which is for instance their battery life. The performance of wearable devices, especially jewels, is much inferior to smartphones: given their limited dimensions, they can only afford to use small-size batteries. Bigger batteries would of course be more powerful, however, they would also reduce the final products’ degree of wearability and comfort, and additional size and

shape-related constraints would then emerge to complicate their design and aesthetics. One of the main goals that is being pursued nowadays is consequently the utmost reduction of battery size while increasing efficiency and, in more general terms, finding ways to power wearable electronic devices as quickly and as easily as possible.

Other problems linked to the combination of hardware and fashion products concerns product maintenance, such as the washing of clothing, fixing in case of faults or malfunctions, and component recycling. Sustainability is presently a rather topical issue, concerning the different ageing rates of traditional fashion materials such as fabrics, as well as the disposal of the electronic parts present in these products (McCann and Bryson, 2009), which is still problematic in its management (Seymour, 2008).

Past lessons have shown that the most successful products with embedded technology are those with an intuitive, easy-to-use interface and which are aesthetically refined: mobile phones, Walkman devices and music players have all become veritable fashion items.

The main goal for wearables designers should therefore be usability and wearability; their products should be able to adapt to the body without impeding natural movements. In his book *The Design of Everyday Things* (1988) Norman listed the best principles for good design: among the top aspects was the requirement that the object be self-explanatory, which means giving consumers a good conceptual model to understand the object itself, clearly marking out the parts to be used, providing directions for use, and supplying feedback on the operation performed. Hence the need for a type of design that makes objects appear intuitive and easy to use.

Simplifying technology is no easy task, however, as the process demands that numerous and complex constraints such as size, correct functioning, technology embedding, aesthetics, functionality and wearability be kept in mind; designers must be able to design as natural an interaction between products and users as possible. Some products available on the market nowadays rely on human gestures; a case in point is Neyya, a ring that takes pictures and manages digital presentations, videos, phone calls and text messages with a simple hand movement. Another example is O2upcycle, a glove linked to a smartphone that enables wearers to answer phone calls simply by raising their hand to their ear. Gestures that repetition has made habitual and automatic in people's daily life are an important starting point for designers intending to plan out a simplified use for complex objects; the goal of this simplifying process is to ensure greater product usability for those who approach technology products for the first time. Indeed, when people are used to repeatedly performing a given action in their daily lives, they no longer perceive it as

an effort; this phenomenon has been variously labelled by researchers – one could mention Herb Simon’s ‘compiling’, the philosopher Michael Polanyi’s ‘tacit dimensions’, the psychologist TK Gibson’s ‘visual invariants’, or John Seely Brown’s ‘periphery’ (Weiser, 1991, p. 78) – and highlights the importance of a non-invasive perception of technology (Berry, 2014).

A by no means secondary goal for wearables designers is thus user value, what the relevant literature imprecisely describes as ‘user experience’; in the present discussion this expression will designate products and services as a whole that can generate user value. On the basis of Osterwalder and Pigneur’s approach, the generation of user value has been described as a company’s ability to provide their users with product and service benefits. The service revolves around supplying awareness-raising information on innovation. In this sense, a source of knowledge on products, behaviour and meanings are for instance social networks, as they actively involve users in content creation and in knowledge exchange among peers, and as such constitute a learning context within wider social interaction (Baird and Fisher, 2005). The attention which these writers devoted to users, who are also millennials, may be extended to inclusive design, as in the design process developed by Henschel and Mirande (2014). Product and service prototyping and the analysis of product impact on user experience are of paramount importance, as they can lead to unexpected results. Redström (2006) maintained that a discrepancy between the products’ planned use and their actual employment by end-users will always be inevitable, and on more than one level; he therefore stressed the importance of designing products which make allowance for this dichotomy. Designers should, therefore, always be alert to the end users’ possible behaviour and perception with regards to the product they are designing.

The Project Within Fashiontech

The Premise

The analysis carried out with the support of some of the relevant literature (Tenuta, 2017; E4FT, 2018) indicated that the limitations of fashion products with embedded technology aimed at the consumer market are mainly the consequence of structural deficiencies within the businesses active in the sector, which appear to struggle with handling all of the project aspects in a uniform way. As was shown, these limitations do not just concern products in the strictest sense: they do not concern merely the products’ technical side, their materials or their aspect, but in fact affect the whole relevant user experience.

Market analysis and references in the literature have highlighted this sector's fragmented nature, as professionals, disciplines and diverse skills manage to combine themselves satisfactorily only with great difficulty (E4FT, 2018).

Despite widespread interest towards this emerging trend, a hybrid structured methodology capable of streamlining the process, promoting dialogue systematically and merging the various approaches together has still not been properly defined. This situation indicates a lack of dialogical harmonisation among the various sectors involved (E4FT, 2018), and has repercussions for the quality of the designed products and experiences.

FashionTech is the highest point of cross-fertilisation between fashion, industrial design and IT; aesthetics, comfort, the users' central role and usability are all applied to the electronics and digital technology sectors, the advancements in which and progress in multifunctionality, performance, size and costs are FashionTech's main driving forces. In consideration of the complexity of the approaches and of the diverse actors that are involved in it, it becomes indispensable to develop a common code that may ensure a greater degree of communication among all these sectors and, by extension, encourage synergies among the various processes.

The main goal of this part of the discussion is attempting to define a methodology that can actually reconcile fashion design processes and engineering approaches. Its achievement could bring about the training of more versatile professionals: these could potentially manage the growing research on wearable technologies, in view of developing new skills and designing innovative products that can enhance user experience, perform better, and be more aesthetically appealing.

This research will therefore now turn to the streamlining of the design process especially in the context of academic training, with the ultimate goal of subsequently applying the outcome to non-academic practice.

Towards a Hybrid Process of Product Design

At this stage in the present discussion it is perhaps advisable to list those contributions which have been instrumental in the development of this research's practical part.

Worthy of special mention is the study carried out by Tenuta (2017), as it demonstrated that traditional fashion design methodology is ill-suited for the production of products with embedded technology. Fashion's design methodology generally envisages an initial briefing stage to define the task, investigate user needs and desires across the sectors, ascertain which products and

competitors are already on the market, as well as to identify trends, materials and the most suitable innovation techniques. A concept is then developed through a brainstorming session to evaluate and select the best solutions that can fulfil parameters determined in advance, namely the product's ergonomics, aesthetics, functionality, performance, materials and costs. Sketches and technical drawings follow suit in order to develop preliminary prototypes which will pave the way for the actual products. Whenever both fashion design methodology, like the one described above, and engineering approaches are employed in the design of fashion products with embedded technology, they are either applied separately and alternately, or else in an imbalanced ratio (Tenuta, 2017). A comparison between the two shows that the main differences concern their initial stages: engineering's starting point is careful, scientifically-approached market research based on wholly technical specifications, whereas the preliminary stage in the design of fashion products focuses on the analysis of trends and user needs. Indeed, while fashion design needs to identify a suitable target, the same requirement does not apply to technology product engineering.

Another important difference between the two processes lies in the final stages of product validation: fashion design methodology envisages a step for the removal of any flaws from the designing canvasses before proceeding with the physical creation of the product, whereas the engineering process entails a step for technical and functional assessments by means of quantitative tests.

Tenuta's tests (2017) have been particularly useful in the definition of a methodology, as they emphasised the importance of correctly identifying the context of a product within the design process. It is a practice that has been borrowed from interaction design, and it consists in delineating a detailed description of the specific context in which products will be used; it goes well beyond the portrayal of user needs and includes characters, behaviours, gestures, and environments. It is one of the most creative stages of the design process: the graphic representation tool known as storyboard illustrates in chronologically-ordered sequence drawings the most important moments within the context of use, and potentially lists the shapes, materials and technologies which will eventually be included in the project concept.

The Design Experience

Hands-on experience belongs to the field of applied research, and in the present instance it has been carried out on the basis of a number of design activities within the FashionTech sector. The ultimate goal was the inves-

tigation and comparison of various design methodologies by means of an analysis of the degree of innovation present in the ensuing final products; the outcome would then make drawing conclusions on their relevant processes possible. The first test was based on a technology-driven approach, the second was design-driven, while the third relied on a mixed approach.

The evaluation parameters adopted to measure the resulting products were drawn from the qualitative model first proposed by Mancini (2017): he favoured a phenomenological approach (Bertola and Manzini, 2006) to the definition and the evaluation of design innovation based on the observation and the analysis of the elements, labelled ‘Grip factors’, which enabled a number of specific products to survive market and social changes. An inclusive and humanistic model, it takes into consideration the complexity of the contemporary scenario as a whole: innovation is seen as the connecting node between creativity, planning, design, synthesis, creation, intuition, and novelty. These terms play a fundamental role in every innovative design project: innovation is only the final outcome of diverse actions performed in a different order. Unlike creation, the concept of innovation is always associated with the introduction of improvement, and can be applied in actual practice (Schumpeter, [2013]). Moreover, as Luciano (2010) observed, innovation is fickle and relative, as it is deeply tied to the context in which it occurs; it follows that these characteristics greatly complicate the assessment of each process parameter. The Grip Factor Evaluation (Mancini, 2017) is a tool that was developed to illustrate graphically the level of strength or weakness linked to each of the factors listed below by assigning them a score. It can be applied to all of the stages in the innovation process: to benchmark analyses in order to compare product characteristics, to the preliminary research stage to identify weak aspects on which to concentrate innovation, and to the evaluation stage to establish the improvement needed for a newly designed product as opposed to the previous model. The Grip Factors Evaluation is of a discretionary nature and is clearly affected by the compiler’s judgement and amount of experience; indeed, Mancini claimed it is not possible to achieve an exact objective product evaluation methodology because of the level of uncertainty and risk at the core of every innovation process. Its usefulness lies mainly in the possibility to make evaluations that are more structured and systematic, as it provides a reminder of the factors that can positively affect product dissemination and reception thanks to its multidimensional approach to innovation. Mancini has also stressed the need to set up a pecking order for each Grip Factor depending on the product sector under

examination¹. Mancini's parameters have been adapted to the needs of the sector under examination; exceeding importance has not been attached to the 'Ease in finding' factor, however, as the present case did not deal with commercialised products. Each parameter was awarded a maximum of 5 points.

¹ The Grip Factors Evaluation is composed of the following:

1. Interpretation (1A. Clearness of Meaning: it concerns product meaning, content, message, value and affordability; 1B. Specific Answer: The degree to which products provide a specific solution to a specific need (Munari, 1981); 1C. Satisfy the Needs: Since all products meet one or more needs, grip increases if a given product meets needs closer to the bottom in the hierarchy of needs developed by Maslow)
2. Formal Values (2A. Completeness: the balance between shape and function; 2B. Beauty: elegance and formal refinement are often successful parameters that can positively increase Grip)
3. Technology (3A. Material Optimisation: the ability to make the most of the possibilities provided by materials. It also has positive repercussions on sustainability and affordance 3B. Complementary Materials: the creative use of a mix of materials according to need)
- 3C. Availability of the Technology: the degree of availability of the technology employed to produce objects)
4. Ergonomics (4A. How to Handle the Product: the degree of ease and comfort in using the products; 4B. Safety: the degree to which products avert postural complaints, or even remedy issues linked to body movements)
5. Plus (5A. Change in the Behaviour: the way in which products influence user behaviour; 5B. Necessity Gradient: it designates the fashionable trend towards a point of no return, after which they become indispensable for users; 5C. Second life: Grip also increases when the objects' second life has been thought out and planned, as is the case with their storage when not in use)
6. Sustainability (6A. Prediction of the Consequences: Grip increases if products are sustainable in their use, shape, materials, life cycle, and recycling provisions; 6B. Moral Value: objects that do not exhaust too many natural resources, do not harm future generations, and encourage their users to adopt an environmentally-aware behaviour have more chances to last on the market)
7. Scenario (7A. Communication Skills: the degree to which products support and promote communication, interaction and sharing. ICT technology has been greatly boosted thanks to its ability to influence users in this sense; 7B. Multicultural Appeal: achieved when products can be appreciated by more than one culture; 7C. Ease in Finding: Grip increases if the objects can be found and purchased easily; 7D. Multi-Generational Benefit: the degree to which products may be used by more generations)
- 7E. Auto-Innovation: the degree to which standardised norms are met.

Case Study: Technology-Driven Processes.

Smart Bag Project | Politecnico di Milano

Goal. The purpose of the pilot project was the exploration of designing and prototyping procedures within the FashionTech sector, with a special focus on a case study of smart accessories commissioned by a renowned international sportswear company. Part of the same goal also concerned the success evaluation of a tech-driven approach as regards the relevant products' degree of innovation.

Project Brief. The brief envisaged the re-designing and the prototyping of a smart backpack that could afford users a multisensory experience thanks to embedded technology. The project was therefore developed by using an extant product supplied by the brand as starting point. The actors involved were asked to employ virtual and physical prototyping methods and technologies, in order to turn said backpack into an interactive object that could encourage users to explore new possible uses.

Location and Project Timing. The workshop lasted five days, and was carried out on the premises of Polifactory, an interdepartmental research laboratory housed by the Politecnico di Milano University that investigates the relationship between design and new digital production processes, and promotes a new creative culture. The chosen location was strategically suited to the purpose: it is a research hub devoted to experimentations on advanced manufacturing, whose areas of interest range from distributed production to the designing of highly interactive services.

The Actors Involved. The workshop was organised by the University Department of Mechanical Engineering in cooperation with the Design Department, and involved a motley, multidisciplinary group of actors: 20 international PhD students from the Polytechnic University of Milan, drawn from the Fashion Design, Product Design, Interior Design, Design Engineering, Mechanical Engineering, Electronic Engineering and Architecture sectors. These were divided into four mixed groups.

Methodology. The project envisaged a learning-by-doing part which was compounded by theoretical lessons imparted by international experts in Neuroscience, Mechanical Engineering, IT and Electronic Engineering, Sound Computing, Interaction Design and Fashion Design; these supported the whole design process, and guided the actors through all of its stages.

The Outcome. The products designed by the various groups envisaged very diverse scenarios and contexts of use which included safety, active wear, mobility needs and work wear. The groups that embedded technology and redefined product aesthetics most successfully were those that were more homogeneous in their makeup, and could best combine the designers' know-how with the engineers' hardware and software skills. Product analysis showed that Mancini's model needed to be amended with the introduction of two useful evaluation factors. Firstly, the item 'originality' designating the degree to which the project supplies an original solution for the issue at hand was added under 'interpretation'; secondly, the item 'coherence' concerning the matching degree between the objects' aesthetics and the relevant brand image was added to the parameters on aesthetics. Indeed, it has been remarked that there is the need to make the notion of beauty comply with brand aesthetics, as formally irreproachable projects can still be totally out of line with the client brand's aesthetics. The groups' various outputs brought to the fore the difficulty of meeting some of the parameters fully and coherently, especially as far as the relationship between shape and function, originality, feasibility and consistency with the brand image are concerned. The high degree of integration between fashion and technology, and the associated positive outcome in terms of feasibility and originality, generated a kind of aesthetics that did indeed reflect product functionality, but was not consistent with the company's traditional brand image. Whenever the traditional brand image was complied with and was implementable from a technical point of view, conversely, the proposed solution tended not to be very original. Finally, if the traditional brand image was complied with and the project relied on original solutions, the necessary technology was still too experimental, underdeveloped or expensive for the project to be seriously considered for industrial production. The various actors cooperated on every development stage of the process, and constantly redefined its planning, technical and aesthetic constraints in order to reach their shared goal. As this case study has demonstrated, it is not advisable to start a design process that merely adds new technology-based functions to an already existing object; the final result is a lack of consistency between shape and function.

Case Study: Design-Driven Processes. ***Smart Jewellery Project | Politecnico di Milano***

Goal. The exploration of a design process based on a design-driven approach and applied to smart body ornaments; also an assessment of design's

contribution to innovation when a scenario previously defined by the client was adopted as starting point.

Project Brief. A startup company founded in the context of MIP (the Politecnico di Milano's School of Management) strove to design a device aimed at preventing instances of violence against women and at ensuring their safety in a mainly urban setting. Their team had already identified the technology that could support the development of this project, and required help to design the ornament's outer shell.

Project Timing. The project was carried out in over three months, with actors meeting at regular intervals.

The Actors Involved. The project team included 4 marketing experts, 1 electronic engineer and 1 fashion designer.

Methodology. Designing experience.

Process Stages.

Startup company (4 marketing experts)

- Market research and analysis
- Definition of possible project scenarios
- Identification of the project idea
- Brief launch with the electronic engineer to identify the necessary technology
- Brief launch with the designer
- Concept development and aesthetics development (shape, materials, interaction)
- Seeking funding
- Jewel and technology prototyping
- Test

The Outcome. The project was originally developed in an uneven fashion, with little harmonisation among the parties involved. The technologies were selected a priori by the team without involving the designer, and although they did make the device independent from the smartphone, they negatively affected the product by making its size too cumbersome. The team believed that making the device independent from the mobile phone would constitute a great competitive advantage over similar products already on the market, but did not consider that the hardware's excessive size would negatively af-

fect the aesthetics of a product that was to be worn on a daily basis - even though it might hopefully never be needed.

From a functional point of view there is a number of products available on the market that offer a similar service; hence the importance of creating added innovation value by means of its design and its reliance on gestures and symbolism.

Case Study: Mixed Processes. Smart Bag Design at Politecnico di Milano

Goal. Analysing a design process based on a mixed, transdisciplinary approach (Vacca and Warshavski, 2016) and applied to the development of accessories with embedded technology. The experience detailed below was an instance of participant observation in applied research.

Project Brief. Each group was asked to develop a collection of smart accessories from the design stage to communication and sales. The object under examination was in this case a bag, whose main function as object holder could offer interesting food for thought as regards the interaction between content and container. What is more, the usual size of this type of accessory would allow for greater freedom of experimentation, with none of the technical constraints deriving from hardware miniaturisation.

Project Timing. Regular stage-gate reviews were scheduled in order to monitor the development of the project.

The Actors Involved. The project involved three teams, each of which included a designer and an electronic engineer; these were not newbies, but had already taken part in similar projects at university level.

Methodology. A learning-by-doing approach. The actors were left free to manage the process autonomously, and to test its underlying dynamics of interaction.

The Outcome. The products entailed different scenarios, relied on diverse types of interaction, and in each of them the user interface was a different bag component. As far as aesthetics and technology awareness were concerned, none of the projects used a screen as interface, and in no case was technol-

ogy hidden under an outer shell; rather, the technological side was made tangible through user gestures and a dynamic interaction with the products. In all three projects the technological side and the aesthetic characteristics were combined in a relationship of mutual interdependence and functionality. This approach shows that user awareness as to the presence of technology may not necessarily be something to be avoided, and that technology need not be concealed at all costs; indeed, technology has the potential to improve product functionality or performance, and if properly planned and embedded it can even become an important element in the products' final look. The definition of appropriate scenarios and the development of personas enable dynamic, relationship-based experiences to which products are improving additions. The project participants continuously shared knowledge and processes throughout all the relevant stages, and thus developed a generative methodology (Vacca and Warshavski, 2016). Crucial in this sense were the stages centred on scenario definition and persona development, that is to say, the description of the specific end-users to whom the products were destined. Nonetheless, the groups were in fact forced to have a shared design methodology throughout the project. The engineers included in each team were not merely called upon to develop the products' technical side in the last stage of the project, but did in fact play a fundamental part in the creative process by engaging in constant dialogue with the designer and by regularly updating the project constraints. Right from the initial scenario definition and persona identification, the groups felt compelled to deal directly with potential users, and spontaneously decided to engage them by means of unstructured interviews and through the empirical observation of their behavioural interaction with the relevant products. The groups also elaborated a definition of communication and a marketing strategy. In view of the fact that their dynamic products would require the provision of user instructions, they decided to explain their functioning simply and directly in videos and on websites.

A Proposal for a Methodology for Wearable Technologies Based on a Scientific Approach and on the Creative Process

The experiments described above led to the tentative development of a hybrid methodology that combines some elements from both the fashion design and the engineering methods. The two approaches are combined together to tackle problem definition, as well as to investigate user needs and desires,

the fashion market, current trends, and those innovation technologies that are ready to be applied to industrial production. The initial definition of basic requirements is followed by the most creative part of the project, in which brainstorming leads to the generation of a specific future scenario. Products are centre stage, and become the focal interaction point between users, environment, and other objects. Equally important, nonetheless, is the correct identification and analysis of specific personas on whom to tailor the project. These steps are crucial to set the project on the right course: the procedure enables designers to identify with a specific set of users and to understand their needs and issues in order to develop the project originally. The proper management of the two stages, moreover, has positive repercussions for the subsequent definition of a precise concept; it also eliminates the widespread inclination to equip objects with too many functions, and even enhances the relationship between their shape and function. The concept stage witnesses the identification of materials, shapes and interaction dynamics by means of technical sketches; experimental prototypes are then completed, tested and evaluated. Qualitative checks, which are typical of the engineering approach, are in place, and are matched by a qualitative assessment that tests user experience by measuring the intensity of the users' emotional response to product interaction. All these steps must be necessarily managed by designers and technology experts, as only the joint application of their respective skills may lead to successful products (Tenuta and Testa, 2018).

Conclusions

The contribution of this research

A toolkit

Although there is widespread and growing interest in FashionTech, as the present study has convincingly demonstrated, the data from the market survey shows that businesses operating in this sector are still extremely disorganised and struggle to manage the various stages of the design process in a systematic fashion.

In order to achieve a satisfactory degree of harmonisation it has been necessary to review the methodology and role of the professionals involved. Awareness was raised of the fact that the whole process cannot be managed by a single professional, as it requires a variety of skills if innovation is to be generated, and it was pointed out that a code shared by all the professionals involved must be developed. In order to explain how intrinsic limitations

may be overcome, a methodological proposal has been presented which provides an alternative to fashion's traditional design process, and which is the result of a test on wearable technologies.

This data could be a useful tool not only in academia, but also for the market, as it can foster interdisciplinary knowledge, and it can link and combine fashion's and IT's design process, thereby pushing the boundary between creativity and the scientific method.

The design methodology proposed here has been recently supported in its validity by the data presented by the E4FT report (2018). Through the comparison of data obtained from interviews in research centres, universities and start-up companies, the document identified some of the most important stages of the design process in this sector, and these fully match the ones suggested here; the report, nonetheless, did not deal with the stage concerning the precise identification of personas.

This study also tested the renewed design process in various contexts, found support for its approach in real practice, and bridged, as it were, academic studies on the topic with hands-on experience in the market.

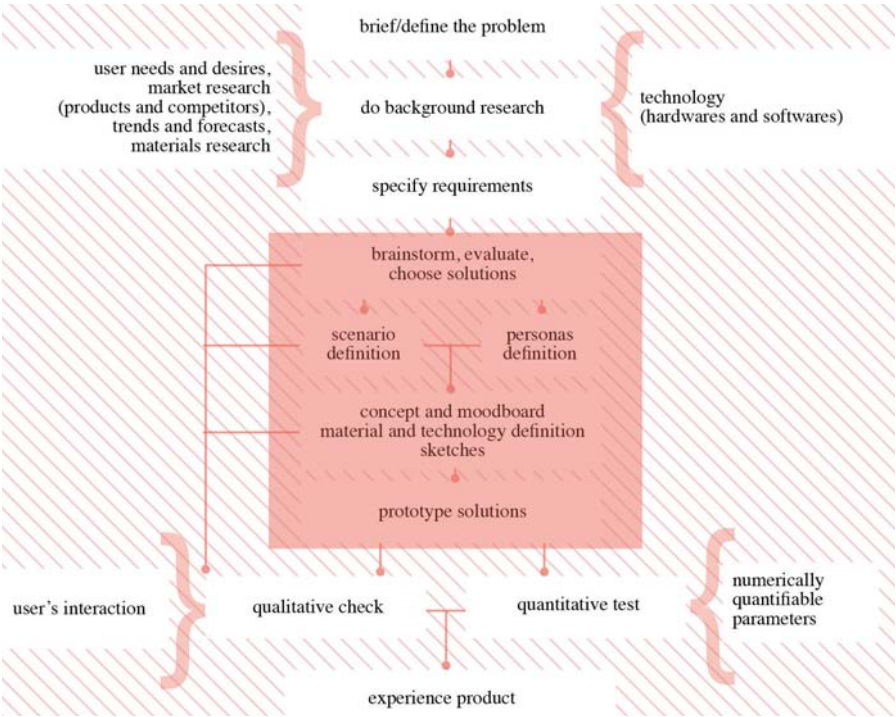


Fig. 1 – Fashion Wearable Design Method.

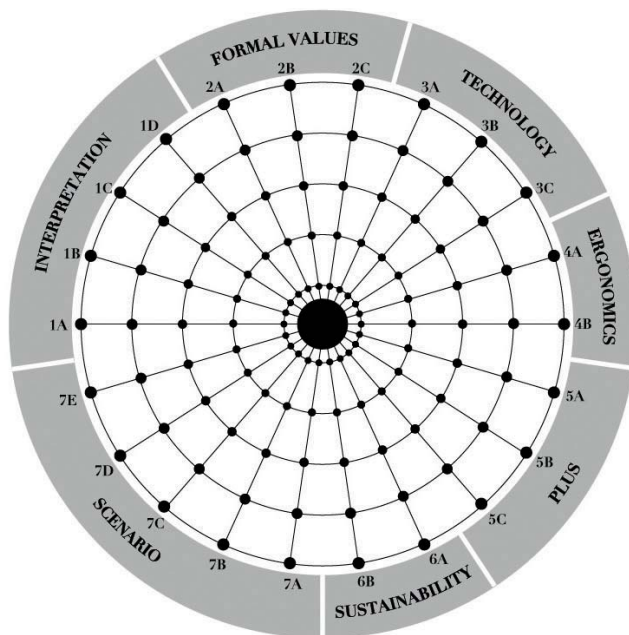


Fig. 2 – Grip Factors Evaluation for Fashion Wearables. 1. Interpretation (1A. Clearness of meaning; 1B. Specific answer; 1C. Satisfy the needs; 1D. Originality). 2. Formal Values (2A. Completeness, 2B. Beauty, 2C. Coherence). 3. Technology (3A. Material optimisation; 3B. Complementary materials; 3C. Asset of the technology). 4. Ergonomics (4A. How to handle the product; 4B. Safety). 5. Plus (5A. Change in the behaviour; 5B. Necessity gradient; 5C. Second life). 6. Sustainability (6A. Prevision of the consequences; 6B. Moral value). 7. Scenario (7A. Communication skills; 7B. Multicultural appeal; 7C. Ease in finding; 7D. Multi-generational benefit; 7E. Auto-innovation).

It therefore proposes a toolkit of sorts for those who have just started familiarising themselves with fashion products with embedded technology which provides a systemic collection of updated case studies illustrating the best and worst practices, and which especially brings to the fore those elements capable of generating an added value for consumers; in addition to this, it also offers practical tools to support the design process. It includes a proposal on design methodology, a comparison of the various approaches to the project (whether tech-driven, design-driven, or transdisciplinary/mixed), and discusses the pros and cons of each of them; it also supplies a framework – streamlined under the influence of Mancini's proposed model (2017) – to measure and evaluate the designed products' innovation impact on their specific sector of reference.

A clarity of purpose

The entire study stresses the importance of integration in FashionTech. In terms of products, FashionTech must combine fashion and technology, whereas, in terms of processes, it needs to bring together science and creativity, diverse forms of knowledge and codes, professionals and actors, and cross-cutting skills that range from science to design and marketing. The need to have professional experts in economics who could provide insight into market trends has also been emphasised.

To this end this work vividly discussed the importance of cross-cutting approaches to the project. Involving the various actors in contexts of shared designing, especially during their university training, would help young designers to become more flexible and more open to dialogue in a perspective of shared objectives. During their training designers could develop the foundations necessary to appreciate the technical side of the development of the technology, hardware and software needed for the project; engineers, conversely, could get the chance to become acquainted with the creative process and the basics of design. These hybrid professionals will subsequently be able to mediate between other participating experts and will guide them towards their shared project goal by ensuring that the tools necessary for knowledge transfer are supplied.

Indeed, as the great design masters have shown, designing does not mean inventing new shapes, but rather originating new behaviour.

Critical Points and Suggestions for Future Developments

It is impossible to ignore the presence of critical aspects concerning the theoretical analysis and the market survey, which mainly derived from poor access to the sources: the ones available to the present writer were numerically limited, and not all of the necessary information was easily accessible to the public. The data relating to sales volumes from the businesses active in the sector was especially scant.

Other limitations of the present work concern practical experience. The analysis presented here is mainly qualitative, and only well-defined groups of participants were engaged. Moreover, the tests carried out here have only been compared with a limited selection of market experiences, and therefore offer only a partial overview of the relevant phenomena.

Another shortcoming has to do with the non-homogeneous nature of the objects used in the tests: the design experiences were performed on a wide range of fashion items, which has not made data interpretation any easier.

As for the definition of the design methodology for wearable technology presented here, the most critical points which still await a full solution concern the relationship between shape, function and brand identity in those cases in which a project is to be developed for a company with well-defined aesthetics. Future studies may therefore examine the possibility of applying and sharing methodology in various contexts, in order to record, analyse and measure other data; special attention and analysis ought to be devoted to shape, function and brand identity, and to their mutual relationship in fashion products with embedded technology.

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