GFC GLOBAL FASHION CONFERENCE 2021

Developing a Fashion-Tech Educational model. Hybridizing design, engineering, and business management education

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Abstract

Background scientific research: A radical transformation has invested the textile, apparel, and fashion sector due to the encounter with technologies from ICT, biotechnology, and biochemistry and propelling the industry toward a 4.0 industrial revolution (Bertola and Teunissen, 2018). New offered products and services, professional activities, and the skill set of fashion employees need combined design, technical and business-related skills (Kalbaska and Cantoni, 2019). The convergence between design, technology, and business management in the activities within the fashion companies is reflected by the necessity for designers to expand their connective rules and abilities among different stakeholders and implement their understanding of technologies and engineering knowledge (Sun and Zhao, 2018). Research (Fashion-Tech Benchmarking Report, 2018) states the fragmented Fashion-tech sector searching for normalization, standardization, and shared language and knowledge among different organizations (HEIs, companies, and research centers) to define Fashion-Tech. Due to its constantly changing nature, updated educational curricula and models should be set up to fill existing and upcoming skills gaps (Fashion-Tech MA Curriculum, 2018; Kalbaska and Cantoni, 2019; Edu4Fashion Tech Design Tuning Document, 2018; Lee, 2020; Colombi and Teunissen, 2020;). Besides, continuous improvements and updates of the training curricula are needed to face the increasingly complex roles of designers (Oxman, 2016; Cross, 2000). An attempt to boost the dialogue between technology, design,

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and business management among actors with different disciplinary and industrial applicative sectors is run in the project Fashion-tech Alliance (2021; Colombi, Teunissen and Vellesalu, 2020; Teunissen and Danjoux, 2021), an Erasmus+ knowledge educational alliance that aims to support innovation and creativity through partnerships and interdisciplinary approaches, to enhance the quality and relevance of students' knowledge and skills, to test and release open and innovative educational practices that will boost students' employability and innovation potential. Taking care of future fashion-tech talents means taking care of the future development of the fashion-tech industry, applying technology for a responsible innovation toward an inclusive, equitable, and sustainable change (Rinaldi, 2019).

Research issue to be addressed: This study proposes an overview of the issues related to the needs of hybridizing fashion, technology, and management disciplines in educational curricula toward an integrated, interdisciplinary and international educational model focused on the convergence between the creativity of design and fashion, the technological aspects of engineering and the managerial and planning attitudes from business disciplines toward an advanced fashion-tech design education. The paper aims to describe (i) the process used to co-design a new educational model for fashion-tech future talents developed by the joint discussion among different HEIS (Politecnico di Milano - School of Design; ESTIA École Supérieure Des Technologies Industrielles Avancées; Högskolan I Borås; University of the Arts London - London College of Fashion; Technische Universiteit Delft); (ii) the guidelines and approaches of the educational model allowing the cooperation and collaboration among different disciplines (design, fashion design, design and engineering, engineering and business management); and (iii) the emerging areas and topics where the integration of fashion design and technology show to be essential to investigate the limits and opportunities of the enhanced technology and Design dialogues toward a hybridized creative and engineering thinking.

Methodology used: The definition of the Fashion-tech educational model was theoretically elaborated through the combination of both empirical and desktop research. In particular, the results gained from the Focus Groups were used to define an integrated curriculum model blending industry competencies and academic knowledge of the Fashion-Tech sector. Besides, desk research focused on innovative pedagogical models such as challenge-based learning (Nichols et al., 2016), Flipped Classrooms (Berrett, 2012), and Social Learning (Bandura, 1997). From this premises, an instructional co-design process was designed by the participating HEIs, following a participatory decision-making methodology based on quick consensus discussions, to reach an agreed definition of the fashion-tech format/educational model to be tested through three Fashion-tech learning experiences.

Achieved and expected results: The paper will present the format/educational model in a list of guidelines that include insights and feedback from the HEIs and Companies perspectives' and encourage the in-depth cooperation, interconnected thinking, and iterative interdisciplinary processing: flexibility, convergent education from multidisciplinary to interdisciplinary learning, common glossary definition, companies

involvement, interaction and engagement, real-world challenges, personalized learning, and openness. The limitation set by the actual academic rules will be discussed. Furthermore, the paper will reflect on convergency topics where fashion design and technology require significant attention to hybridize skills to enhance collaboration and innovation among designers and engineers. In particular, limitation and opportunities will be discussed in light of the possible innovation in the merged creative/engineering approach in these Fashion-tech areas: digital fashion, spanning from virtual modeling toward augmented reality and artificial intelligence, bio-based/biodegradable materials and chemical processes, circular design/engineering, smart textiles, and digital/connected wearables. Describing the areas from the two opposite perspectives at various stages of the design process (research, development, testing/prototyping), we will highlight how to increase interdisciplinarity approaches and learning experiences. This paper is expected to inform different audiences such as researchers, academics, trainers, and practitioners toward possible new converging educational methodologies and interdisciplinary educational programs.

Keywords: Fashion-tech; design; engineering; educational model; convergence education; digital fashion; smart wearables

ISBN: 978-989-54263-2-4

1. Introduction

The encounter of digitalization, information and communication technologies (ICT) and material sciences such as biotechnology, and biochemistry with fashion has propelled a radical transformation of the sector toward a 4.0 industrial revolution (Bertola and Teunissen, 2018). New products and processes can be designed, and new services envisioned, thus enabling new professional rules in need for a hybrid set of fashion-tech skills, placed halfway between design, technological and business-related disciplines (Kalbaska and Cantoni, 2019). Fashion designers claim the necessity to expand their communicative skills toward different stakeholders and implement their knowledge about technologies (Sun and Zhao, 2018).

The Fashion-Tech Benchmarking Report (2018) states that Fashion-tech sector is fragmented and in search of normalization, standardization, and shared language among different organizations (HEIs, Companies, and Research Centres) to find a structured definition. It is difficult to establish Fashion-Tech boundaries due to the number of intersecting disciplines and the continuous technological transformation, expansion, and upgrade (Bertola and Teunissen, 2018). Due to the constantly changing nature of fashion and fashion-tech, new resilient and tech-savvy professionals in the sector should be capable of planning, managing, and leading research and development processes in a very fluid way, handling horizontal and interdisciplinary skills along with vertical skills on specific subject-related contents at the intersection of fashion, design, technology, and management. Therefore, updated educational curricula and models should be set up to fill existing and future skill gaps of fashion-tech hybrid professionals (Fashion-Tech MA Curriculum, 2018; Kalbaska and Cantoni, 2019; Edu4Fashion Tech Design Tuning Document, 2018; Lee, 2020; Colombi and Teunissen, 2020). Taking care of the education of future fashion-tech talents means taking care of the future development of the fashion-tech industry with the overall aim of applying technology for responsible innovation toward an inclusive, equitable, resilient, digital and sustainable change (Rinaldi, 2019). Entangled knowledge (Oxman, 2016), convergence education and the impact design have on culture, society, and the environment (Cross, 2000) crucially demands training skills valuable to the formation of resilient and interdisciplinary future fashion-tech professionals.

The paper presents a preliminary desk research focusing on convergence education between the creativity of design and fashion, the technological aspects of engineering and the managerial and planning attitudes from the economics and business disciplines toward an integrated, interdisciplinary and advanced fashion-tech design education. The second part describes applicative experimental learning experiences run inside the project Fashion-tech Alliance - Weaving Universities and Companies to Co-create Fashion-Tech Future Talents[1] (Colombi, Teunissen and Vellesalu, 2020; Teunissen and Danjoux, 2021). The study aims to describe (i) the process used to co-design a new educational model for fashion-tech future talents developed by the joint discussion among all the partners[2] participating in the FTAlliance project; (ii) the guidelines and approaches of the new Fashion-Tech educational model allowing the cooperation and collaboration among

fashion design, engineering and business management; and (iii) the emerging areas and topics where the integration of fashion design and technology show to be essential.

2. Literature review

2.1 The importance of convergence education

Convergence of two or more disciplinary fields, majors, and subjects in education (Nissan and Niroomand, 2006) is the new paradigm of the academic world. It aims to cultivate future-proof talented professionals with enhanced specific disciplinary domain mindset and broader interdisciplinary knowledge that increase creative problem-solving abilities (Baek, Cho and Kim, 2019). The convergence of science, technology, humanities and social sciences in educational curriculum reflects the complexity and fluidity of modern reality where those areas are intertwined (Carnevale et al., 2011). Convergence allows learning knowledge beyond the borders of conventional academic disciplinary domains with the scope of fusing and integrating them toward a common interest. Since companies are gradually demanding highly competent human resources with the expertise of different disciplinary domains, convergence education can respond to this labour demand (Baek, Cho, and Kim, 2019). To foster employability, convergence educational curriculum, practices and models should be established among HEIs at both organizational and instructional level. The Bologna Process (2005) was the first attempt to foster the adoption of convergence in European HEIs by establishing comparable criteria and standards toward quality assurance. However, this seems not enough. New educational contents, practices, and methods should be tested to reach feasible convergence educational models.

2.2 Convergence between design and technology in teaching methods and skills requirements

During the past 50 years, design education for designers has significantly changed in terms of pedagogy and contents. Compared to the design skills and practice being taught in school for future professionals in agencies and companies since Bauhaus (Cross, 1983), the focus of design education had made a significant shift towards a broader context of Design thinking. This design thinking approach aimed to support designers to work collaboratively to actively deal with the dynamics of societal demands and issues by combining a broader spectrum of skills, methods, and tools (Oxman, 2004; Koh 2015; Wrigley, 2017). However, compared to the product design becoming complex and diversified, design thinking results were often oversimplified, limiting the designers to persuade their contributions to different industry and societal partners (Dorst, 2010). To overcome these limitations, scientific and systematic approaches have been emphasized in design methodologies along with the development of quantitative evaluation and corrective measures (Cross, 1993, Ertas, 1996). Starting from the first generation of linear hierarchy model (Jones and Thornley, 1963) of analyzing problems– synthesizing problems– evaluating solutions, the second generation was focused on the recognition of satisfactory or appropriate solution-types (Simon, 1969) from the clients' or users' perspective. In the 70s and 80s, these approaches diverged into different fields of architecture and engineering with respective models and design processes that tended to the detriment of both (Roozenburg and Cross, 1991).

By understanding the commutative nature of problem and solution (Archer 1979), a new multilayer and cross hybrid design model was described where design problems were solved by integrating complex perspectives in the design industry (Cross, 1989).

While reflecting these significant shifts in design methodologies, the fundamental goal of design education has shifted by focusing more on the purposes and goals of the design criteria (such as usability and sustainability) than the design outcome (Sanders, 2008). Design became an academic discipline in universities by promoting convergence with science and technology. Students gained various knowledge, informal experience, practical skills, and shared knowledge among different disciplines. A project-based design program has also been developed in several universities to promote collaboration among students with different design, engineering, social sciences, and business background (Voûte, 2020). Students and researchers were encouraged to develop their research field with the convergence between design and technology as part of the research method (Horváth, 2007). Ph.D. programs were established to mature design as an academic discipline as a part of the design-specific phase of education. Students with various backgrounds have carried out interdisciplinary research projects achieved as independent researchers under the university-wide standard (Kleinsmann, 2011). However, during these convergence processes, design is often approached as a basic frame to integrate complex concepts of engineering and other social prospective (Shin, 1997). Along with the focus on problem-solving, designers' engagement to bring creative solutions needs to be fully emphasized without being diluted (Seo, 1995).

2.3 Examples of convergence in fashion-tech design

Convergence education in the fashion-tech domain aims at combining the creativity of fashion design, the technological side of engineering, and the humanistic and social scientific side of economics and business management. This kind of education promotes the merge and hybridization of problem-solving engineering approaches and the creative thinking of design approaches validated with the pragmatic perspective of economics for a reality check in the business domain. The main examples available in the literature refer to the application of convergence education between fashion and engineering within the development of smart wearables (Han, Wohn and Ahn, 2020; Baek, Cho and Kim, 2019; Lee, 2020). These studies show a very close focus on convergence educational experiences about technologies embedded in fashion items to guarantee functionality along with aesthetics and wearability, lacking the business and project management perspective and the widest applications of Fashion-Tech sector also expanding the focus on societal and sustainable-related challenges and issues. Conversely, nowadays is clear that fashion-tech is a very wide and fluid sector, not just limited to technologies embedded in garments and accessories but considering the digital and technological transformation impacting the whole fashion supply and production chain to reach innovation in product, processes and systems (Bertola & Teunissen, 2018) with a critical impact on the environment, culture, and society.

3. Methodology

This study focuses on three research questions:

- Which are the most viable guidelines on which educational curricula, models, and practices could be established to nurture future fashion-tech skills?
- How can we boost the dialogue and the knowledge exchange between technology, design, and business management?
- Which are the challenges /limitation and benefits/advantages of convergence Fashion-Tech education both in organizational and instructional terms?

To explore deeper these issues, we piloted one learning experience on digital and virtual fashion design, and we set up and implemented other two ones focusing on the scalability of fashion-tech solutions with a sustainable and societal challenge and smart wearable technology impacting more the user experience toward more sustainable choices and ethical use of data. The following paragraph describes the co-design and implementation of learning experiences. Results are presented focusing both on learning materials and educational structure implementation (1st, 2nd and 3rd learning experiences) and on students' observation and feedback on convergence and interdisciplinarity collected during the 1st learning experience (since at the time of writing the paper, the other two ones were in progress). The discussion section highlights achievements and limitations to inform future Fashion-tech learning experiences.

3.1 The co-design process for a new Fashion-Tech educational model

The definition of the Fashion-tech educational model was elaborated through the combination of both desktop and empirical research. Firstly, the Fashion-tech educational model was informed by the results of a series of focus groups that were organized between HEIs and Companies to reach an Integrated and fine-tuned curriculum model blending industry competencies and academic knowledge in the Fashion-Tech sector. From this dialogue a good practice on Fashion-Tech curriculum with guidelines on new pedagogical practices emerged (Teunissen and Danjoux, 2021). The co-design process continued inside the different HEIs of the FTalliance project through meetings and workshops aimed at exploring, at first, their disciplinary expertise to be considered in delivering the courses and lecture materials. A map about teaching activities, course expectations, and learning standards highlighted areas of hyper-specialization but also interconnections, and possible gaps: Design and communication (UAL – LCF), Design and manufacturing (POLIMI), Manufacturing and Engineering (ESTIA), materials and Engineering (TUD), and Business Management (HB). Consequently, following a participatory decision-making methodology based on quick consensus discussions, both instructional (e.g., learning objectives, attended results, contents, and learning materials) and organizational (e.g., structure, timing, selection criteria for students' participation) decisions were taken to define a shared syllabus to be tested in three pilote learning experiences. Decisions taken in the participatory instructional planning activities both with Companies and HEIs were confronted with current pedagogical models to lay a

solid methodological foundation for the format/educational model. Desk research focused on innovative pedagogical models such as challenge-based learning (Nichols et al., 2016), Flipped Classrooms (Berrett, 2012), and Social Learning (Bandura, 1997). The results section highlights the main guidelines and approaches of the Fashion-tech educational model that has been tested in three learning experiences. It also describes the convergence areas of Fashion-tech aimed at bridging the gaps between the two different perspectives of fashion design/design, engineering processes, and business management: digital and virtual fashion design and smart/digital/connected textiles and wearables. For each area, the convergence of the learning experiences is unpacked in order to evidence the interdisciplinarity approaches aimed at boosting the dialogue between the disciplines.

4. Results

4.1 The guidelines and approaches of the Fashion-tech educational model

The Fashion-Tech format/educational model has been conceived in the following framework of guidelines:

Learning Flexibility aims to accommodate differences of HEIs in organizational and instructional terms with teaching and learning activities implemented according to the learning objectives and a flexible course structure to be delivered digitally.

Common glossary definition aims to share a common language and basic knowledge among team members allowing the various disciplinary experts to communicate easily and understand each other points of view. To facilitate this communication exchange, learning experiences should be based on a multidisciplinary literacy in order to hybridize students' knowledge, and to give an overview of the complexity of the sector.

Learning experiences aim to *pass from multidisciplinary to interdisciplinary approaches* within teamwork. Each learning experience will include students with different disciplinary backgrounds, sharing diverse expertise and perspectives in the Fashion-Tech sector. While approaching the problem-solving activities students share similar goals but look at the fashion-tech topic from their own discipline's point of view. From a multidisciplinary sharing knowledge, students will reach an interdisciplinary modality of working together overcoming the limitations of singular forms of inquiry and addressing the complex problems in societies and organizations (Conklin, 2005). Multidimensional problems involving social, cultural, economic, technological, and environmental components are formulated to promote interdisciplinarity and to find solutions that are beyond the scope of a single discipline but require the collaboration of many.

*Teamwork a*ctivities should be performed in groups that include students with specific expertise and educational backgrounds in the sectors that characterize Fashion-Tech. A collaborative and participatory approach in fashion-tech projects' development enable to shift the perspective from a single and partial vision to a choral and inclusive one, allowing shared knowledge and integrated solutions.

Interaction and engagement are an essential part of the learning happening among learner-teacher, learner-learner, and learner-content to ensure a connected student experience (Moore, 1989). Literature review

shows that there are unequivocal links between engagement and student success, learning and achievement (Sinatra, Heddy, & Lombardi, 2015). Moreover, engagement is particularly important in on-distance and online educational contexts where drop-out is a problem.

Companies' involvement is fundamental to increase the interaction and to bring the students close to real-world challenges. It becomes increasingly crucial to create a synergy between real problems and challenges of Companies and the research-oriented approach of universities. Therefore, company experts should be integrated into the course preparation, teaching, and coaching activities.

Stemming from specific input of the companies in the Fashion-tech sector, *real-world challenges* will be answered by interdisciplinary teamwork. Group members can take on complementary professional roles with a multidisciplinary approach: people from different disciplines work together, each drawing on their disciplinary knowledge toward a common goal (Stember, 1991). By the end of the interdisciplinary project development, students will be able to integrate knowledge from different disciplines, using a real synthesis of approaches, hybridizing knowledge and methods from various disciplines, and creating their holistic perspective based on this. As stated in the literature (Nichols et al., 2016), challenge-based learning (CBL) is better for long-term retention of materials, developing 'replicable' skills, and improving students' attitudes towards learning, that becomes more meaningful, and purposeful. The reason relates to the fact that the challenge spring from the real-world, emerging situation, context of application, problem, and issue.

Coaching and mentoring In CBL means that both students and teaching staff are involved as learners. By moving beyond the traditional academic hierarchy, they work together to meet academic objectives while solving real-world challenges. The general goal is to provide a more trustworthy and mature professional learning experience for students, addressing their learning needs while supporting their emotional growth, and social development.

Personalized learning refers to instructional approaches intended to address individual student's distinct learning needs, interests, aspirations, or cultural backgrounds. Following a student-centred learning perspective, personalized learning is based on increasing the personal responsibility students have in the instructional process, and the "student voice" to express their values, opinions, beliefs, perspectives, passions, and ambitions. This could be allowed by customizing their learning plans, by enabling navigation and selection of learning units and modules of the theoretical part, setting the pace of learning activities to a certain extend and also selecting the challenge that mostly reflect the student's interests, and career aspirations.

Openness refers to open–knowledge of lectures, educational materials and models that are made widely accessible as open educational resources (OERs) via the project platform and distributed to international fashion-tech education and research HEIs for the international teaching community.

4.2 The three learning experiences of FTalliance project

The guidelines of the educational model have been tested in three pilot Fashion-Tech learning experiences. These have been spaced between over a period of one year to test the challenges, limitations, problems and benefits/advantages related to the reached convergence. They were also differentiated in terms of contents provided to students and Fashion-Tech specific application. The three courses were:

- Fashion-Tech Interline. The virtual dimension of fashion design (7 January – 8 March 2021)
- The secret life of clothing: Tracking and Sensing in Smart Fashion (29 September – 1 December 2021)
- Scalability of multidisciplinary F-Tech solutions: addressing future sustainability challenges (13 October – 30 November 2021)

The courses explore how fashion, technology and business management are interconnected impacting the design, prototyping, production, sales and project management processes and focusing on faster, smarter, and more efficient garments, considering both the sustainable and societal challenges.

The courses are held completely on-remote digital learning modality due to Covid-19. The structure is based on a propaedeutic / introductory theoretical part (DISCOVER) aimed at leveling the basic fashion-tech knowledge of students from different disciplinary backgrounds, gaining each other disciplines' perspectives on a common topic. Theoretical pillars (design, methodology, technology and business modules) provide a variety of lectures about theory and application examples preparatory for the next DESIGN part so that cross-disciplinary facilitation occurs. An updatable digital literacy catalogue contains various in-depth courses on different topics that students can consult asynchronously, defining their study plan depending on their previous expertise. The modular lectures aim at improving their multidisciplinary understanding in terms of glossary and methodology. In the DESIGN phase, students work in international groups, to experience an interdisciplinary methodological approach of a project development activity that includes design, engineering, product and materials management, costing, and pricing. In the following paragraphs, the results of the implementation and delivery of convergent learning experiences will be discussed.

4.3 Digital and virtual fashion design

The first course focused on the opportunities of the digitalization of fashion considering both digital and virtual fashion technologies transforming the whole fashion design, production, selling, and consumption processes and focusing on the ways today's fashion businesses can become smarter, more efficient, and sustainable. Both in the Discover and Design part the learning experience focused on two strands of future abilities: sustainability (materials, processes, design, and business models) and digitalization (design, testing, simulating, visualizing, fitting, and experiencing).

Convergent areas of Fashion-Tech

In between Design and Technology, digital and virtual fashion is found to impact design processes through 3D modeling, rendering and visualization expertise, 3D pattern making, and design through CAD drawings. These

convergence areas are changing the design, product development, and prototyping processes in terms of creativity, sustainability via technological opportunities. It also impacts the buying spaces (digital platform) and experiences both in terms of design (e.g. digital and omnichannel narration and storytelling, user experience, user interaction, customer journey experience in omnichannel, e-commerce platforms through online, digital showrooms) and in terms of new business model (BM) innovation (e.g., service-based BM, value propositions). At the intersection between the three disciplines, digital fabrication and advanced manufacturing technologies are impacting the design and production development of garments and accessories. Besides, technical abilities in 3D modeling for additive and subtractive manufacturing coupled with fashion design skills in terms of aesthetic and stylistic research allow to nurture abilities of digital fabrication along with the ability to plan a local production in urban micro-factories.

Theoretical pillars organization

Theoretical pillars were organized to support these interlaced skills with propaedeutic lectures to share a common understanding among students from different disciplines on digital fashion, spanning from virtual modeling toward augmented reality and artificial intelligence. Lectures focused on giving insights on the trends and the phenomena of 3D digital and virtual fashion applications, lectures on how to develop near and far future scenarios. Methodological lectures were focused on 3D modeling and virtual prototyping of garments. Applicative practical lectures were provided to teach the students how to use a specialized fashion 3D modeling and rendering software, going through the interface, the 2D-3D modelling from simple to complex garments, basics of materialsdigitalization, and virtual prototyping for 3D mapping, texturing, and photorealistic simulations. A specific technological focus was directed to 4.0 technologies at the service of circularity: Industry 4.0; Circularity; Technologies for circularity actions. SDG operationalization for digital fashion value chains and the perspectives on the digital value chain and business model development were provided as basic knowledge for business management of innovative digital fashion-tech Companies.

Challenge-based learning part

3D Modelling transformed the manual craftsmanship-based methodology of designing and pattern making, changing the way fashion design students could study, envision, and visualize the designed collections. 3D garments could be designed, simulated, prototyped, modified, personalized, and tailored in a digital world before becoming physical prototypes with increased accuracy. Furthermore, designing digital garments became more complex and engineered, including materials, geometry, manufacturing processes specifications that could be carefully defined beforehand, thus facilitating innovation. At the skills of trend research, concept definition about the inspirational theme and material and style research, fashion designer could gain 3D modeling skills, enabling newer creativity opportunities and visualization capacities, even though their impact with the software was not always totally user-friendly. Engineering students, on the other side, were skilled in the use of the software, also able to create metaverse where the collection could be

showcased but were enabled to grasp the aesthetical, conceptual, cultural intangible aspects of the fashion design process. New product and services were collectively designed by defining new innovative business models and changing the value-chain, and reflecting on the sustainability impact of the entire fashion supply chain. A focus on the sustainable practices related to design (e.g., circular pattern design), technologies (e.g., material recyclability, micro-scale/on-demand/local manufacturing), and business models (e.g., circularity, re-commerce, etc.) inside the Fashion-tech domain was collectively achieved. In addition, the set of skills explicitly referring to facilitating new business models and entrepreneurship/intrapreneurship in the Fashion-Tech sector were also addressed in the course, by asking the students to act as a small start-up managing the business from idea development to pitch toward hypothetical financial investors.

4.4 Smart/e/digital/connected textiles and wearables

The second and third course promoted students' collaboration by learning different approaches and methodologies in the smart/e/digital/connected textiles and wearables, connecting this application to sustainable and societal challenges.

Convergent areas of Fashion-Tech

Smart/e/digital/connected textiles and wearables are considered the next game-changer in user-centred products and systems by enhancing user's interaction between the physical and digital environment (Chae, 2020). smart/e/digital/connected textiles and wearables could provide new perspectives and values in the future of fashion. As a material that interconnects textile, electronic systems, and computer science, they are frequently selected as a medium to facilitate the convergence education model across fashion and technology (Lee, 2020; Han, 2020). Their design and implementation require a combination of skills that allow technological selection, integration and programming, user experience testing, sensors and actuators integration into fabrics and threads. In addition, it is crucial to complement fashion, design and engineering skills with studies about the innovation of business models that allow the success of smart textile and garments and their correlated services. These skills are linked to interdisciplinary knowledge about life cycle assessment, recyclability of mixed technologies and materials, and new circular business models. Interdisciplinary collaboration is also required in understanding handling data derived by the digital/connected wearables from both design, technological and economic perspectives. Data science (e.g., data collection, interpretation, analysis, management, and governance) integrated with a sensibility to fashion, textile processes, and end-user/customer needs are explored to increase sustainability, forecasting trends, and improve the integration inside the entire project workflow.

Theoretical pillars organization

A series of lectures have been developed and delivered as part of theoretical pillars to provide the common ground of knowledge of smart textiles and wearables, by integrating design, engineering, and social aspects to give a balanced and interconnected overview on the subject. Two technological lectures on sensors and

actuators for smart textiles applications and soft and textile-based sensors were developed to provide an overview of available and off-the-shelf technologies along with sharing the basic electronic concepts, coding, and programming. A methodological lecture was provided to assess the smart clothing and wearable systems' experience through different approaches, methods, and tools to measure the various dimension of comfort to evaluate wearability. Lastly, a lecture on the sustainability of smart textiles was added to initiate a reflection on the recyclability of integrated and advanced technology. Along with the use of precious materials for their production, the challenging factor of sustainability in Smart Textiles Product was mainly discussed related to the user behaviour, product life span, and disposal patterns, as their market is closely related to fashion and electronic devices. Other general lectures provided an overview on sustainability of the fashion sector related to environmental, economic, social and cultural sustainability. A series of methodological lectures focused on designing user experiences and interactions, through low-tech prototyping and design ethnography methodologies applied to fashion-tech.

Challenge-based learning part

Considering that the planned CBL design activities are conducted digitally, a physical, onsite, hands-on smart textiles workshop on prototyping with smart textiles was not possible due to the nature of the tangible prototyping activities that could not be performed in groups. Differently, to accomplish the convergence of education on a digital learning environment, students are asked to work on data that can be retrieved and revealed by fashion wearable technologies. The scope of the learning experience is to design better user interactions having a higher environmental, social, and economic sustainable commitment. The course guides students through a process of research-informed design ideation for an interactive wearable technology concept that has both technological implications and requires business-oriented choices.

5. Discussion and conclusion

This paper presents the implemented format/educational model blending feedback and cooperation from HEIs and fashion-tech Companies to encourage interconnected and iterative interdisciplinary learning experiences: flexibility, convergent education from multidisciplinary to interdisciplinary learning, common glossary definition, Companies' involvement, interaction and engagement, real-world challenges, personalized learning, and openness. These guidelines have been applied in three pilot learning experiences to test how students with different disciplinary backgrounds were able to learn and collaborate in convergence education to respond to complex design briefs. The practical limitation set by the actual academic rules in terms of organizational features such as the misalignment of academic calendars, the different bureaucratic procedures to build new courses. and the overlapping academic commitment of students and teaching staff were partially solved by creating a two-step educational framework: theoretical pillars could be followed in an asynchronous modality, meanwhile the challenge-based learning part was structured in groups' tutoring sessions along with the creation of a digital collaborative board on MIRO where all students could access the

other groups achievements and project development. Despite this, the richness of having students from 5 HEIs working together in interdisciplinary groups in the first learning experience has also been extremely difficult to manage due to not aligned academic calendars, commitment and students profile. The following courses has been organized to include a lower amount of HEIs to simplify the organizational level without reducing quality of convergence education and interdisciplinarity.

Furthermore, the paper reflects on convergence areas where fashion design, technology, and business management require to share knowledge, hybridize skills, enhance collaboration in the two applications tested in the learning experiences: digital fashion, spanning from virtual modeling toward augmented reality and artificial intelligence, and smart/digital/connected textiles and wearables. The paper highlights how to increase interdisciplinarity approaches in both theoretical and practical learning experiences that could be useful both for researchers, academics, trainers, and practitioners toward possible new interdisciplinary educational programs. The asynchronous discovery part allows students to reach a shared digital literacy via modular theoretical units to be consulted asynchronously and preparatory to the challenge-based part. The synchronous design part was based on teamwork activities to conduct a complete interdisciplinary experience of project development allowing the students to get transversal skills enabling the collaboration across disciplines and also specific and sectoral skills to sharpen their disciplinary expertise (T-shaped skills). Even if at the time of writing the paper the two courses about smart, digital, and connected textiles and wearables were under development, the learning approach and materials have been used to develop an interdisciplinary smart textile course for the 3rd year of Bachelor students at the Delft University of Technology. Lecture materials of the theoretical pillars were selectively shared with students after being adjusted by considering the change of the audience from fashion-engineering to design-engineering discipline. After the theoretical lectures, three workshops were launched to design and prototype different smart/digital/connected wearables and textiles using different soft sensors. Through the hands-on workshop, a convergence of knowledge and soft skills was successfully demonstrated through interdisciplinary collaboration by encouraging design-engineering students to work together as a group. The smart textile workshop is a valuable result elaborated as a subsequent development of design methodologies and education of the FTalliance project. Convergence education is crucial to prepare fashion students but also engineers and business managers to be the hybrid professional of tomorrow able to interact together, to be resilient in a context of continuous transformation toward digitalization of products, processes, and systems and to have a critical approach in terms of sustainability.

6. Acknowledgements

This article is the result of a common research and findings undertaken by the authors working as partners in the European project Erasmus + KA Fashon-Tech Alliance. We acknowledge all the components of the HEIs, Research Centers and Companies participating in the knowledge alliance.

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[1] Fashion-Tech alliance is an Erasmus+ knowledge educational alliance that aims to support innovation and creativity through partnerships and interdisciplinary approaches, to enhance the quality and relevance of students' knowledge and skills, to test and release open and innovative educational practices that will boost students' employability and innovation potential.

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