MAKING EDUCATION: EXPLORING DIGITAL FABRICATION POTENTIAL WITHIN FASHION DESIGN LEARNING PROCESS

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Abstract
The complexity of contemporary society is requiring more and more approaches that leverage on interdisciplinary knowledge and hybridization of methodologies and tools. This awareness is increasing in each discipline, Design is also assuming this perspective.

Within a design-driven context, the interdisciplinary approach has been extended even further by introducing digital fabrication tools and processes. The integration of digital fabrication in product development practices doesn't impact only on manufacturing processes, but potentially affects all stages of the industry, from design to consumption. The necessity to explore potentials and limits of the technology is requiring an iterative definition of new methodologies, blurring the borders between disciplines and performing practical and inclusive paths. This kind of approach is experienced within Fab Labs, networked and distributed laboratories equipped with a common set of digital fabrication tools supported by a global creative community, built upon knowledge sharing programs, peer to peer education, and access. The diffusion of urban collaborative spaces allowing users to prototype personal and professional solutions [1,2], are fostering the rise of new business models based on digital craftsmanship, on-demand and tailored production [3], and distributed manufacturing.

Within this evolving context, the role of educational institutions should be to catch and explore innovation potentials from emerging realities, in order to train professionals capable of overseeing these new practices, being ready to cope with updated market dynamics. Through approaches driven by Project Based Learning (PBL) [4] and learning by doing, it is possible to face this complexity, breaking down challenges in circumscribed frameworks without reducing or limiting the scope of research.

In view of this analysis, the paper will present a pilot educational experience, that has been prototyped within the Master of Science Course “Design for the Fashion System” of Politecnico di Milano, which aimed at (a) training designers in understanding the impact of digital fabrication technologies in modifying and implementing fashion design practices, (b) testing the integration of knowledge and skills from different professional figures involved in the management and proposal of an interdisciplinary project, (c) evaluating the potential of digital fabrication technologies in fashion practices, by assessing their effect on product and process innovation.

In particular, the pilot has been performed as a workshop involving twelve students, and lead by a senior fashion designer, a digital fabrication expert, and a facilitator. The pilot's experience included students’ self-assessment and reflection on the process carried out, built on the model usually adopted to document hands-on activities within Fab Labs. An assessment phase conducted by the facilitator followed, in order to validate the PBL model and improve it in anticipation of being repurposed in future didactic experiences.

Keywords: interdisciplinary education, project-based learning, fashion design process, digital fabrication.

1 THEORETICAL FRAMEWORK
In recent years, emergent technologies are generating profound transformations in the fashion industry, driving a paradigm shift that is challenging traditional systems and dynamics. As Crewe [5] states, these emergent technologies are blurring the borders between brands and consumers, production and consumption, material and virtual worlds, producing an impact throughout the whole supply chain. In this evolving context, the role of designers is becoming increasingly complex [6,7].

As a matter of fact, according to Sun and Zhao [7] the evolution of the industry reflects more interactions among the designers, manufacturers and users, requiring designers to expand their skillset in order to act as a “ringleader” in directly communicating with various stakeholders of the
network. Considering the overlapped roles between designers and manufacturers, scholars expresses
the need for designers to implement their understanding of emerging prototyping/manufacturing
technologies and improve their engineering knowledge related to digital fabrication. Digital fabrication
is the process of converting 2D and 3D digital files in physical objects by using a computer-controlled
machine, such as 3D printers and cutting machines. The integration of digital fabrication on product
development does not impact only on manufacturing processes, but potentially affects all stages of the
industry, from design to consumption.

In fact, the large availability of these digital forms of production are prompting the development of
innovative industrial model promoted by start-ups like digital craftsmanship, on-demand & bespoke
production, and distributed manufacturing as alternatives to mass production [3], fostering and
enabling self-production and self-entrepreneurship [8,9]. The possibility to directly interact with
disruptive technologies, such as digital fabrication tools, is requiring designers an approach that
leverages more and more on ‘interdisciplinary’ knowledge [10] and on the hybridization of
methodologies and tools. The necessity to explore potentials and limits of these novel technologies is
driving the research towards new methodologies that break the boundaries between disciplines,
opening up to more practical and inclusive paths.

This type of approach is widely adopted within Fab Labs (acronym of Fabrication Laboratories),
networked and distributed local laboratories equipped with a common set of digital manufacturing
tools, supported by a global creative community of technologists, designers, researchers, and makers
[11,12]. Fab Labs’ core features are knowledge sharing, peer to peer education, learning by doing,
access instead of ownership, and the “power of diversity” [13, p.7]. The active participation of
professionals from different backgrounds and the open knowledge culture behind Fab Labs allow the
establishment of heterogeneous glocal networks that favors the exchange and dissemination of cross-
sectoral knowledge and the development of innovative projects.

Thanks to a set of technological, human and structural resources, Fab Labs are considered as spaces
from which designers can benefit in several ways. Specifically, according to the whole set of services
Fab Labs potentially offer, fashion designers can (a) enhance their digital manufacturing skills, (b)
pursue self-production and micro-production, (c) rapidly prototype ideas and projects, (d) implement
and test interactive projects and systems, (e) experiment textile/fashion orientated researches, (f) hold
workshops, (g) connect and interact with professionals from inside the fashion industry (other
designers, artisans and companies) or traditionally outside it (IT, engineers, etc.), and actively
participate to collaborative design paths [14].

Within this evolving context, the role of educational institutions should be to catch and explore
innovation potentials from emerging realities, in order to train professionals capable of overseeing new
practices, being ready to cope with updated market dynamics [10,15], Mikhak et al. [11, p.6] affirms
“[i]t is […] imperative that significant resources be committed to innovative approaches to learning and
the development of tools that deeply recognizes the differences in human learning.”

Therefore, one of the most important issues is to find effective ways to enable designers to acquire the
wide range of competences necessary to fully understand the running potentials of digital fabrication
tools in fashion design practices. Several educational experiences carried out within the context of Fab
Lab [16,17] have demonstrated that approaches driven by a Project Based Learning (PBL) model
supported by learning by doing can be effective to help learners construct knowledge while using tools
to make things.

2 METHODOLOGY

In view of this analysis, the paper presents an educational pilot that has been prototyped within the
Master of Science in “Design for the Fashion System” at Politecnico di Milano – School of Design and
hosted within Polifactory, the University’s Fab Lab, in June 2018. The pilot was organized as a design
workshop, an intense educational practice, whose duration can vary from two weeks to a minimum of
two days, where students are requested to develop concepts and design product/service solutions
starting from a brief and going through research and analysis, idea generation, concept development,
prototyping, and presentation.

In this case, the didactic experience involved twelve students and was led by an interdisciplinary team
of professionals: a senior fashion designer, a digital fabrication expert, and a facilitator.
The main objectives of the workshop were to train designers in understanding the impact of digital fabrication technologies in affecting and implementing fashion design practices, to test the integration of knowledge and skills from different professional figures involved in the management of the workshop itself, to evaluate the potential of digital fabrication technologies in fashion practices, by assessing their effect on product and process innovation. Given the experimental nature of the experience, the pilot workshop was structured exploring and mixing methodologies and tools, adopting an interdisciplinary approach. Bertola, Cavanna and Vacca [10] define ‘interdisciplinarity’ as an approach whose aim is the knowledge exchange among different domains, where specific cognitive approaches and methodologies are shared to collectively redefine the process itself. The interaction within an interdisciplinary context is bidirectional and active, and supports the enrichment of all the stakeholders involved, fostering the development of innovative paths. The scholars also assume that this approach could be applied by academic institutions performing problem-based centered experimental courses, where new learning formats are developed, project-based practices are promoted, educational experiences are prototyped to support knowledge exchange among different disciplines.

The preliminary phase of the workshop was carried out taking inspiration from a resource designed to plan and manage interdisciplinary innovation in education: the ‘Pedagogical Development and Integration Model’ [10]. Following these guidelines, different interactions among the professionals involved were planned, in order to establish the workshop (WS) guidelines and features before its delivery.

2.1 Workshop Design

2.1.1 Setting the WS foundations: goals, roles, and constraints

During the first meeting, the common vision on the project goal was established. The partners agreed on exploring the potential of digital fabrication tools – specifically the laser-cutting machine – in fashion design practices, testing an educational experience that could put the basis for future collaborative courses. Furthermore, individual competences and interests in participating to the experience were explicitly stated and distinct roles within the WS were clarified.

The digital fabrication expert, PhD in additive manufacturing technologies and processes in design practices, consultant and technical supervisor within the University’s Fab Lab, had no background knowledge related to fashion. From her perspective, the WS was significant to understand the potential of laser-cutter machine on textile surfaces, whose experimentation has been limited until that moment, because the laboratory was mainly attended by students from Product Design, Computer Science and Engineering. Moreover, she was willing to start collaborative experiences with academics from Fashion Design courses and introduce the laboratory to students in order to stimulate further engagement and experimental experiences, as well as include experiences within the fashion sectors into the Fab Lab portfolio and competences. The role of the digital fabrication expert within the WS was to support students in prototyping with the technology: giving them technical instructions in order to export the right file format to be processed by the machine, setting up machine parameters for cutting/engraving, and starting the manufacturing process.

The senior fashion designer has been building her expertise along more than forty years in close contact with technicians and mechanical engineers within Italian fashion districts’ facilities, developing innovative fashion processes and products through experimenting new techniques and applications of industrial technologies. She had no background knowledge related to digital fabrication tools and processes. Therefore, her interest in the WS was driven by the understanding of the prospective applications of digital manufacturing in the development of fashion products. The role of the senior fashion designer was to perform the art direction of the workshop launching the brief and supporting students in idea generation, concept development, and definition of the fashion product’s formal aspects.

The facilitator, MSc in ‘Design for the Fashion System’ at Politecnico di Milano and fellow researcher at Politecnico di Milano Design department, has been directly experiencing the cross-fertilization of fashion design, electronics and digital fabrication in her education and research experiences. From her perspective the WS was significant to test, evaluate and implement a didactic methodology in order to inform effective future pedagogical experiences. Specifically, the interest was linked to students’ cognitive process in acquiring awareness over how the integration of digital fabrication within the design process could inform fashion practices. The role of the facilitator was related to: (a) providing students basic theoretical knowledge around fashion and digital fabrication intersections, (b) tutoring
during the whole WS, (c) supporting students in time management, and (d) raising awareness on major challenges to be considered in the development of fashion-related project involving digital manufacturing tools, based on personal experience and literature review.

After a brainstorming activity, team agreed on WS duration, needed equipment, access to spaces and tools, number of students involved, and expected outcome as follows: (a) workshop duration was set at five days, as an intense experience to let quickly emerge potentials, limits and main challenges to overcome in order to improve the pedagogical methodology, (b) laser-cutter machine was chosen as digital fabrication tool, because of its prototyping speed in respect to other technologies, considering the workshop duration, (c) students’ direct access was limited to the machine software for security reasons and time constraints, allowing groups to access the machine room and stand by the digital fabrication expert during the whole manufacturing process, (d) twelve students, grouped into six couples, were involved because only one laser-cutter machine with limited dimensions (40x70 cm) was available, and (e) an apparel item was set as expected outcome in order have reasonable level of design complexity.

In this way, each group was asked to perform iterative tests and realize the final prototypes, challenging its problem-solving skills in consideration of machine’s needed time of production and dimensions as main constrains.

2.1.2 Framing the WS features: methodologies, contents, and organizational aspects.

In this phase, the interdisciplinary team reflected on different aspects of the WS configuration in terms of methodologies to be undertaken, contents, and organizational requirements. The WS roadmap draft was firstly defined and incorporated seven general phases: context overview, launch of the brief, research and idea generation, concept development, testing and prototyping, final presentation, and reflections. As underlined in the theoretical framework, interdisciplinary educational pathways cannot be structured applying traditional methodologies, but exploring and mixing knowledge, methods, and tools from different cognitive approaches.

The context overview was structured to provide students insights around the general topic from different perspectives. The typology of contribution proposed in this first phase was a set of theoretical lessons, field trips and talks from experts reporting their professional experiences. This variety of inputs aimed at helping students familiarise with the topic, developing a shared knowledge around multiple opportunities and running applications of the technologies. After the context overview, students were asked to autonomously rearrange themselves in groups of two components, ready to deal with the launch of the brief, where WS general objectives, timings, deliverables and expected outcomes are presented. The research phase followed the metadesign process: the brief were analysed through a desk research that deepen the topic from both the cognitive and formal perspectives, and iterative brainstorming, concepts were reorganised in form of moodboards, keywords, and questions that could inform the idea generation. Research, idea generation, concept development and testing/prototyping phases has been managed following a Project Based Learning approach. David [4, p. 80] states that

“the core idea of Project Based Learning is that real-world problems capture students’ interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. The teacher plays the role of facilitator, working with students to frame worthwhile questions, structuring meaningful tasks, coaching both knowledge development and social skills, and carefully assessing what students have learned from the experience”.

Indeed, through a PBL approach, it is possible to face complex tasks, breaking down challenges in circumscribed frameworks without reducing or limiting the scope of research. Since one of the workshop constraints was coping with digital fabrication technologies, PBL model was supported by integrating a learning by doing approach in hands-on activities. As a matter of fact, several courses promoted within the context of fabrication laboratories [16,17] have demonstrated that an effective way to help learners in understanding the functioning of a digital manufacturing instruments is ‘learning by doing’, the process of constructing knowledge while using tools to make things.

The WS contents development was mainly carried out through interactions between the senior fashion designer and the facilitator. The specific thematic area and the brief required to design and prototype an apparel item exploring different concepts of fit in fashion, integrating digital fabrication processes in the making of. The contents of the lectures to be delivered before hands-on activities aimed at alphabetising students to be able to reach the expected outcome and to enrich their knowledge on digital manufacturing technologies and spaces, and unconventional ways to perceive the fashion fit.
Theoretical lectures, field trips, and talks led by the faculty team and external experts focused on fashion wearability, Fab Labs and digital technologies, and applications of digital fabrication processes in fashion practices.

In regards to organizational aspects, the digital fabrication expert and the facilitator discussed over the possibility to differentiate educational spaces according to the WS objectives and needs. Theoretical lectures and research activities were planned to take place within the university traditional working rooms equipped with projectors, microphones, and desks and asking students to bring their own laptops. For concept development and hands-on activities, the Fab Lab co-working space and laboratories, as well as the faculty fashion laboratory equipped with tailoring instruments and machines, were made available to students. Given the short timeframe of the workshop, all the materials necessary to design and prototype were provided by the faculty. The selection of fabrics, developed comparing additional expert opinions, were carried out considering the interaction of materials with the high-power laser beam of the machine, used both to cut and to engrave. Among the selection criteria there were texture, composition, and weight of the fabric.

2.1.3 Sharing the WS plan: agenda and deliverables

Referring to the contents of the workshop, faculty presentations were internally shared, collectively reviewed and implemented according to the common vision. An overall agenda of the workshop was set up to be delivered to students. The agenda included information about timing and locations, the contents of the workshop, lectures and experts involved, brief and tasks, deliverables and expected outcomes.

2.1.4 Evaluating the WS: tools and actions

The evaluation of the educational approach was one of the WS main purposes. The work in progress was recorded with photos and videos, in order to keep track of key moments and progresses.

Different assessing tools and actions were adopted to identify guidelines for future development of similar interdisciplinary courses. The formal didactic assessment of students’ performance was formalized in two moments: at the intermediate presentation performed after research and idea generation phases, and in occasion of the project final presentations. During the evaluation phase, the following criteria were taken into consideration: (a) quality of the research, (b) relevance of the concept with respect to the brief, (c) presentation of the project in the different phases and understanding of the process, and (d) quality of the prototype. Evaluations were delivered to students in form of grades and detailed feedback.

During the workshop, students were asked to document the process, taking picture and notes of all the design and manufacturing stages. At the end of the workshop, they had to deliver a report including the documentation of the whole process carried out. The digital template of the report was designed and delivered to students before the beginning of the prototyping phase, in order to help them scan the different phases of the project development. The written report included: (a) project general information (brief, project name, abstract, inspirational board, keywords and sketches), (b) project making information (bill of materials, tools and software, the step-by-step design and prototyping process, the laser-cut parameters), (c) the final outcome (the digital pattern and photos of the product), and (d) the team’s considerations (findings, difficulties and overall conclusions). The need to keep track of the step-by-step design and prototyping process, the laser-cutting/engraving parameters, and team’s considerations were fundamental as a reflective exercise to increase students’ awareness on the impact of integrating digital fabrication technologies in fashion design practice and learning process. Team’s consideration around findings, difficulties, and overall conclusions gave also interesting insights for the implementation of the pedagogical experience. As well as, direct feedback from the facilitator, the senior fashion designer and the digital fabrication expert helped in re-framing the experience from the managerial perspective.

3 MODELING A FASHION-TECH INTERDISCIPLINARY EDUCATIONAL EXPERIENCE: “EXPLORING FASHION FIT THROUGH DIGITAL MANUFACTURING”

The pilot experience, as presented hereafter, was designed as a 5-day workshop and was structured in different steps, with specific inputs and expected outcomes. The workshop incorporated seven main phases: (1) Context overview, (2) Launch of the brief, (3) Research and idea generation, (4) Concept...
development, (5) Testing and prototyping, (6) Presentation, (7) Reflections. In this section the activities performed are described, underlining the aim of each phase, how it was delivered and considerations.

3.1 DAY 1

3.1.1 Context overview: Theoretical Lecture

Context overview aimed at introducing theoretical basics around the intersection of fashion design and digital fabrication processes and spaces. The introduction, supported by a digital presentation, covered: (a) digital fabrication and reverse engineering tools for rapid prototyping and small scale manufacturing, (b) the cultural and social phenomenon around the democratization of tools, spaces and practices related to making, and (c) the recent diffusion of urban fabrication laboratories, with a specific focus on Fab Labs. Subsequently, fashion-orientated experiences using digital fabrication processes within urban fabrication laboratories have been outlined through case studies, underlining actors involved and activities, potentials and challenges [14]. The majority of students had no previous knowledge around potentials and functionalities of digital fabrication and Fab Labs. In order to support the understanding of digital tools and processes, the explanation was supported by videos showing technologies in action.

3.1.2 Context Overview: Field Trip

After the introductive lecture students visited one of the most active Italian Fab Lab in fashion/textile-orientated initiatives. The aim of the field trip was to raise students’ awareness around the existence of these spaces and to tangibly show them further applications of digital fabrication in fashion design. During the visit, a fashion designer and Fab Lab staff member presented the main activities of the laboratory (current and past courses, events and partnerships), provided a brief explanation of the equipment functioning, and showcased products and prototypes from different sectors of applications (apparel, accessory, footwear, wearables) born from the community experiments and collaborations with designers and fashion companies.

Students were surprised about the existence of a place where they could prototype and test their own projects with direct access to digital manufacturing technologies previously inaccessible. The laboratory was little attended at the time of the visit, this did not allow students to catch the Fab Lab ‘power of diversity’ [13] and to interact with other professional figures.

3.2 DAY 2

3.2.1 Context Overview: Expert’s talk

The aim of expert lectures was to introduce the topic of the brief (body, fit, and digital technologies) from different disciplinary perspectives. The first expert presented a fashion-related topic. The lecture was focused on exploring the various possibilities to manage clothes fit adopting unconventional tailoring techniques, compared to traditional practices of patternmaking. The second expert talked about the intersection of digital technologies and fashion. The lecture was dedicated to a wearable technology case study and introduced to students some of the most important aspects when dealing with digital technologies as: the user interaction, the evolution of formal aspect, and the iterative process necessary to explore the opportunities offered by the technology and to achieve the expected goals. Moreover, it was an example of an interdisciplinary collaboration between a fashion designer and a computer engineer. The third lecture was led by the senior fashion designer, who gave a presentation on her innovative design method, based on the concept that clothes should be designed to free the body and to be timeless, far from the traditional logic of the fashion product, understood as an industrial, seasonal, ever-changing product, linked to the identity of trends. The lecture focused on different ways to explore fit, playing with fabric technical features, textile surface finishing, and unconventional assembly processes. The three presentation were performed projecting virtual presentations and included videos and images. Physical prototypes were showcased.

3.2.2 Launch of the brief

The brief launch “Design and prototype an apparel exploring different concepts of fit in fashion, integrating digital fabrication processes in the making” was aimed at framing the workshop challenge in a clear way, informing at the same time the students about the expected outcomes. Students were grouped into six teams. Refering to general brief, a different sub-brief was assigned to
each team in order to explore a specific topic related to fit, such as “Adjusting”, “Subtracting and Segmenting”, “Folding”, “Wrapping”, “One piece only”, and “Matching”.

### 3.2.3 Research and idea generation

The aim of the research phase was to explore the brief analyzing and discussing visual and cognitive contents leveraging on brainstorming, desk research, and previous experiences/knowledge of the teamwork. During this phase a PBL approach was adopted: faculty members (the facilitator and the senior fashion designer) acted both as facilitators helping students in framing and re-framing the brief challenge in order to stimulate research and ideas generation. The research phase lasted for few hours. At the end of the day each group performed a pechakucha style presentation introducing the team’s brief, explaining the reinterpretation of the topic, showing the research carried out through inspirational images, keywords and case studies, and finally proposing a question/statement that could inform a concept for the development of a fashion product.

Initially, students were asked to present a concept of a fashion product in the form of a sketch. However, all groups had difficulties in defining a preliminary idea. Massive assistance was required in this phase, with clarifications on the brief and on presentation requirements. Many students for fear of not being able to deliver on time, started making sketches without almost starting the search. To avoid this, the faculty decided in progress to recalibrate the expected outcome of idea generation, from a sketch to an inspirational statement to be further defined. At this stage, a higher number of group member would have been beneficial, ensuring a deeper brainstorming. Anyway, imposing students to publicly present the outcome of the research in the limited time available stimulated students’ problem solving and social skills, laying the foundation for concept development, and approaching the prototyping phase.

### 3.3 DAY 3

#### 3.3.1 Concept development

The aim of the concept development phase was to design the fashion product finalizing the previous research, setting up its formal aspects and surface treatments. Sketching was supported by the inspirational research carried out, implemented with further searching on pattern-making/laser-cutting and engraving techniques. The students worked in teams to complete this phase. Most of the groups successfully achieved the definition of the concept within the deadline. The group that found this task extremely challenging was the one whose members had lower knowledge on pattern-making.

#### 3.3.2 Prototyping and testing

The prototyping and testing phase aimed at experimenting the learning by doing approach applied to the analogical and digital making process. During this activity, students split the work according to the specific skills of each team member, in order to simultaneously carry out several steps of the project. The comparison took place mainly when decisions had to be taken or when one of the members of the group had to overcome a problem.

The first prototyping phase was carried out using analogue instruments. Students found different ways to carry out preliminary design test steps, such as using scissors, cardstock and fabric samples. The creation of patterns took place following different methods. Some groups started from standard pattern samples transformed according to project requirements. Other groups focused on zero-waste design and started from a piece of paper. Others built their pattern operating the fabric directly on the mannequin. The prototypes were made out of canvas (in real dimensions or in scale), applied over the mannequins and directly implemented, reporting changes on the paper pattern. This phase was largely supported by the senior fashion designer, because students’ previous knowledge on patternmaking was not advanced.

Almost simultaneously, cutting and engraving details to be obtained with the laser-cutting machine were defined creating design files using a 2D software students were familiar with. Following the instructions provided by the digital fabrication expert, students had to export the files in order to be processed by the machine. Despite the instructions given and the familiarity with the software, students were not able to immediately produce appropriate files because of minor mistakes. Even if this slightly slowed down the test of the first samples, at the same time it allowed students to make direct experience of one of the fundamental aspects when interacting with a digital fabrication tool: the processability of the file. According to the effects each group wanted to achieve, numerous tests were
carried out to understand the interaction of the laser with different materials. Speed, power and acceleration of the laser beam were managed by the digital fabrication expert, involving the students in setting the right parameters. Through various tests students were able to evaluate, recalibrate their activity, approach the machine in a more conscious manner, and obtain better results. The revisions were not planned, students were free to seek the opinion of the senior fashion designer, the facilitator and the digital fabrication expert based on the nature of their problems. The prototyping and testing phase with analogue and digital instruments continued on the following day.

3.4 DAY 4

3.4.1 Prototyping and testing

The second day of prototyping proceeded on test and trials, in close contact with the digital fabrication expert in order to finalise the fashion product. The challenge of creating an apparel coping with reduced dimensions of the laser-cutting machine produced interesting results, stimulating student’s problem-solving skills. The approaches of the students to this limitation were different. Some teams resized the original pattern’s outline to perfectly match the machine dimensions. Other groups, whose patterns were too big to be entirely cut within the space available, found solutions to overcome the problem without compromising the fabric integrity, developing smart ways for placing cuts and engravings selected areas. The major challenge to cope with was time management. Some teams decided to experiment the engraving process, highly time consuming in comparison with laser-cutting. Students learnt that, tracking manufacturing parameters (speed, time, acceleration) when testing on small fabric samples, they were able to forecast the duration of the whole product processing. This instrument allowed them to anticipate time issues and find valid alternatives when necessary: modifying parameters, simplifying the design, or changing the process.

3.4.2 Final Presentation

At the end of the day each group performed a public presentation of the whole process – from brief to research, from concept development to prototyping and testing –, projecting a presentation, showing tested samples and the final product to faculty. Students were asked to explain the different steps necessary to achieve the presented result, to list the materials and technologies adopted, and to specify main challenges faced and solutions found.

3.5 DAY 5

3.5.1 Reflections

Reflections’ phase was a fundamental step to help students develop an awareness on the impact that digital fabrication technologies had in modifying and implementing their own fashion design practice. Moreover, it gave insights on major challenges they went through, allowing to take them into account in structuring future pedagogical pathways.

Students reported that the major issue was the combination of the limited timeframe of the workshop, being six groups and only one machine. Some of them said there was not much time to “make mistakes” during experimentations and to fully implement the prototype, improving the quality of assembly and fit. The two teams that experimented zero-waste design reported that they encountered several difficulties in obtaining a wearable product, due to their unadvanced patternmaking knowledge, to the short time available to implement the prototype fit, and the limited machine dimensions.

Other students commented the machine limited dimensions as a big constraint, some students affirmed that, at the same time, it gave them the opportunity to “think outside of the box” and find creative solutions. The majority of the teams reflected on the relationship between the designer and the technology, i.e. one of them affirmed that:

"It is common thinking that using technologies the design process will be faster, easier and the final product will be aesthetically more beautiful. But this is not true. Technology is just a tool that can support the designer in prototyping an idea. […] It’s up to the designer to make iterative experiments to understand which is the perfect process to obtain what he/she wants. The limits that the technology imposes are the starting point for designers to think in a different way".
4 CONCLUSIONS

The aim of this paper was to validate the PBL model within an interdisciplinary educational experience integrating fashion design practices with digital fabrication tools and processes. Additionally, secondary goals were aligned with the workshop’s objectives: (a) train designers in understanding the impact of digital fabrication technologies in modifying and implementing fashion design practices, (b) test the integration of knowledge and skills from different professional figures within an interdisciplinary context, and (c) evaluate the potential of digital fabrication technologies affecting product and process innovation in fashion practices.

The short timeframe allowed to let quickly emerge potentials, limits and main challenges in order to improve the pedagogical methodology. The results of the study suggested that many of the difficulties encountered could be solved by structuring a course of longer duration, implementing the context overview phase and the learning by doing process according to the following considerations.

The context overview, proposed through a set of theoretical lessons, field trips and talks from experts, resulted very effective. It provided students a shared knowledge blending insights from different perspectives involving professionals with complementary competences. This also reinforced the message that the design process must be hybridized with diversified knowledge domains and methods, to approach interdisciplinary projects. During the workshop, this activity was delivered in one day and half, overstimulating students with a great amount of novel contents. A possible improvement could be to provide students didactical materials – suggested readings, e-lessons, case studies - before the start of the workshop in order to facilitate the comprehension of concepts and acquisition of a preliminary knowledge.

The PBL model approach turned out to be a successful methodology to address research, idea generation, concept development, and testing/prototyping phases: students learnt to cope with complex tasks deploying their problem-solving skills leveraging on individual competences and experts’ knowledge. Moreover, through a learning by doing approach, students acquired empirically technical skills to manage a specific digital fabrication tool. During the testing/prototyping phase, students directly experienced the technology limits and potentials, and deployed as well their patternmaking skills. Ongoing sample tests before final prototyping enabled students to evaluate the process, recalibrate their activity, approach the machine in a more conscious manner, and obtain better results. This methodology could be implemented structuring the prototyping practice on several small theoretical and practical exercises, in order to allow students gradually understand the technology functioning. Once this application capacity would be acquired, they could move on and design the final project which could be more or less complex, based on their level of experience and knowledge acquired in the testing phase.

Furthermore, the final report template helped in keeping track of the whole design process, and constituted a useful resource for multiple reasons. It facilitated students in framing the evolution of the manufacturing process and it enabled a reflection on the experience, raising the awareness on applications and implications of the technology in fashion design practices. The report has also provided to faculty an additional instrument to evaluate the students’ work and to assess the efficacy of the workshop itself.

In conclusion, the myth that digital technologies allow to do everything right away were debunked. In fact, digital prototyping probably takes as long as a sartorial process. Having a tool does not replace the designer’s knowledge. Digital technologies do not fill knowledge gaps and don’t substitute traditional technical fashion knowledge. One supports the other to innovate while previous knowledge is highly needed.

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