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WHEN FASHION EXPRESSES THE HYBRID: DIALOGUES BETWEEN DIY MATERIALS AND DIGITAL FABRICATION IN FABRICADEMY'S FINAL PROJECTS

QUANDO A MODA EXPRESSA O HÍBRIDO: DIÁLOGOS ENTRE MATERIAIS DIY E FABRICAÇÃO DIGITAL NOS PROJETOS FINAIS DO FABRICADEMY

Brunna Gonçalves Ramos[1*], Elisa Strobel do Nascimento[2], Marta Karina Leite[3]

[1 2] Federal University of Paraná (UFPR), Curitiba, Paraná, Brazil. [3] Federal University of Technology – Paraná (UTFPR), Curitiba, Paraná, Brazil.
[1*]brunnagramos@gmail.com [2]elisastrobel@ufpr.br [3]martaleite@utfpr.edu.br
*** Corresponding Author: Ramos, B.B.**

ABSTRACT: This paper aims to contribute with Fab Labs fashion design with DIY (do it yourself) materials. These workshops contribute to a more sustainable posture toward fashion showing the array of possibilities presented by such materials, which usually are considered as biomaterials. For the study, the method of Documental Research was implemented in the analysis of final projects from *Fabricademy* - Textile and Technology Academy from Fab Foundation course. Four final projects were mapped, projects from the years 2023 and 2024, and that merged personal fabrication materials to digital technologies in the creation of fashion products. The objective was to comprehend how this interconnection makes possible to create authorial sustainable artifacts with added value and an aesthetic that makes the relation between hand-machine procedures evident, while the academic contributes for the diffusion and enhancement, although future studies may amplify the analysis scopus.

KEYWORDS: Digital Handmade; DIY Materials; Digital fabrication; Fashion Design

RESUMO: Este trabalho busca contribuir com a difusão de práticas de design de moda em Fab Labs com o uso de materiais DIY (*do it yourself*, ou faça você mesmo). Estas contribuem para uma postura mais sustentável da moda ilustrando as possibilidades desses materiais, que geralmente se configuram como biomateriais. Para isso, foi utilizado o método de Pesquisa Documental para análise de projetos finais do curso Fabricademy - *Textile and Technology Academy* da *Fab Foundation*. Foram mapeados quatro projetos finais desenvolvidos nos anos de 2023 e 2024, que integraram materiais de fabricação pessoal e tecnologias digitais na criação de produtos de moda, a fim de compreender como acontecem tais interconexões. Os resultados apresentam os insumos utilizados, os processos de obtenção e pós-processamento, os produtos gerados e as principais tecnologias de fabricação digital aplicadas. Conclui-se que essa interconexão possibilita a criação de produtos autorais e sustentáveis de valor agregado e estética que evidencia o processo híbrido entre mão-máquina, enquanto a documentação acadêmica contribui para sua difusão e aprimoramento, embora estudos futuros possam ampliar o escopo da análise.

PALAVRAS CHAVE: Artesanato Digital; Materiais DIY; Fabricação Digital; Design de Moda.

1. INTRODUCTION

This work is an amplified version of the article "*Interconexões entre Moda, Fabricação Digital e Materiais DIY: uma análise de projetos do Fabricademy*" (Interconections between fashion, digital fabrication and DIY Materials: an analysis of Fabricademy projects) presented and available at ENSUS - XII Meeting on project sustainability 2025 congress annals. Beyond further exploration on the subjects, this version also amplifies the research reach by presenting the study in English, aiming to expand the frontiers on the matter.

The investigation presented here has as its starting points the Fab Labs, workshops or laboratories that provide digital fabrication tools for prototyping products under an open project logic (Menichinelli; Schmidt, 2020). Fashion Labs share the same principle with design fashion tools implementation, an example of such is the workshop network *Fabricademy*. Such shared technology spaces bring forth the Digital Handmade movement - a movement that emphasizes artisanal and digital merge - and make possible to explore new materials and processes, encouraging personalization, local manufacturing in small scale and environmental sustainability through the use of local resources.

Our argument is built upon the premise of DIY (do it yourself) materials have the potential to establish productive connections with fashion labs through handmade-digital doing, since they can expand the traditional temporal fabric and fashion possibilities by the integration of vegetal, animal and digital technologies worlds in the creation of new aesthetics and communicative imaginaries (Franzo; Moradei, 2024).

Moving further, as Kohtala (2018) states, alternative material initiatives that take place on workshops such as Fab Labs or Fashion Labs usually occur outside corporative or academical departments, and as such, are normally taken as non-effective, non-scientific or non-relevant (Kohtala, 2018). But, they can inspire scientists to advance the development and the scalability of materials and products propositions (Rognoli; Garcia, 2018). Thus, this work aims to contribute to the diffusion of hybrid practices handmade-digital of fashion design in Fab Labs with DIY materials, while documenting the process as an academic research.

The investigation is guided by the question: "How to analyze the scenario of DIY materials considering inputs and manipulation processes in fashion design and digital fabrication context?". In order to answer to such question, this paper analyze the interconnections between fashion design, digital fabrication and DIY materials under the lenses of a documental research performed in the Fabricademy's final projects collection, from the Textile and Technology Academy course.

First, the study presents a contextualization of main subjects around the research: Fab Labs, Digital Handmade movement, DIY materials and the Fabricademy course. In the sequence, methodological procedures are addressed, both for data collection and analysis. Followed by the analysis of 4 end course projects from Fabricademy, and the presentation of practical interconnection strategies among the addressed subjects. Lastly, the conclusions are presented.

2.1 DIGITAL FABRICATION, FAB LABS AND MAKER CULTURE

Digital fabrication tools were first developed in 1952, when MIT researchers connected a milling machine to a computer, inventing the CNC - Computer Numeric Control (Gershenfeld, 2012). Such machinery allows to locally produce virtual models generated by Computer Assisted Drawings (CAD) by subtractive, additive or conformative processes (Campos; Dias, 2018).

As Gershenfeld (2012) states, this fabrication model allows the transformation of data to physical objects, as well as physical objects into data, since it enables the digital sending of project archives to anywhere in the Earth. In order to do so, one needs only to configure CAM (Computer-Aided Manufacturing) in a software and generate the G-code, a code that contains parameters of speed, positioning and other configurations for the archive execution (Campos; Dias, 2018).

This way, an advantage for those tools is the possibility to modify it or use it in the making process of other tools and machinery, the fact that inspired the creation of the first Fab Lab in the South End Technology Center, Boston, 2003 (Gershenfeld, 2012). These workshops have a pre-setted equipment setting such as laser or vinyl cutters, 3D printers and large sized, high precision CNC milling machines for wood, together with woodcarving tools, electronic bench and microcontrollers for fast circuitry prototyping (Gershenfeld, 2012; Leite, 2021; Fab Foundation, 2025).

Leite (2021, p. 63) also states that the Fab Lab network is managed by the non-profit organization The Fab Foundation “that connects workshops of Digital Fabrication all around the world”. According to the organization, apart from the tools, those labs allow access to abilities and processes that makes anyone able to do “almost anything” (Fab Foundation, 2025). Thus, Fab Labs are deemed as “innovation spaces where one can find new manners to work and to use their space” (Felippe *et al.*, 2020, p. 25).

Fab Labs are also named as makerspaces, a term that is both applicable to their users and the maker movement (Menichinelli; Schmidt, 2020). As a follow-up to DIY culture, this movement relates to old self-sufficiency visions, communitary organization, alternative values, manual labor and domestic abilities. Be it by financial motivation, obligation, opportunity to express artistic expression, or as a Hobby (Kohtala, Boeva, Troxler, 2020). Nonetheless, those actions were remade into a modern, globalized conception (Kohtala, Boeva, Troxler, 2020) in order to make digital fabrication technologies and on-line communities even more accessible (Eckhardt *et al.*, 2021).

Following Von Platen and Kitani (2023), a reasonable amount of maker movement activities work around the opportunities new technologies grant the layperson, as well as the knowledge on how to use them for the personal artifact fabrication. Therefore, solutions are sometimes performed under an open project logic based on on-line repository sharing, magazines and free flow of projects - a practice named as open design (Rognoli et al., 2015; Kohtala, 2018; Eckhardt *et al.*, 2021). This is why it isn't uncommon that users from such spaces download or deposit projects in open access platforms such as the websites instructables.com[1], thingiverse.com[2], and makerworld.com[3].

Menichinelli and Schmidt (2020) state that, in order to allow the replication of their projects, Fab Lab network shares the same protocols, practices, communication channels, and initiatives. One of such is the "Open Day", a day open to the community in which users must only take the materials and inputs needed for the project (Leite, 2021) into their spaces. This is what characterizes the labs as public access committed spaces, even when privately operated, since their essence is in the democratization of fabrication tools (Fab Foundation, 2025).

2.3 DIGITAL HANDMADE

The democratization of technologies and machine assisted production inspired a new creative movement called Digital Handmade (Johnston, 2017). Song (2021) points out that this concept emerged in the 90's, when technologies started to override handmaking processes. The term describes a new aesthetics for our time, capable of being reached only through the fusion between hand and machine, it can be considered also as a contemporary version of arts and crafts movement (Johnston, 2017).

This clashing combination has its own challenges, though: digitally fabricated artifacts are infinitely reproductible, whilst handmade artifacts are manually, individually made by the artisan (Zoran; Buechley, 2010). In this very sense Houlihan (2018) exemplifies that a CAD modelled flower can be 3D printed hundreds of times, while a clay-sculpted flower hardly will be identical to any replica, and, even in order for that to occur, the process must be started from scratch.

In his book "The Craftsman", when discussing manual work, Sennett (2009) argues that the biggest dilemma the modern artisan faces is the machine. He states that the use of machines in production must occur after the evaluation of uses potential and adaptation to our own limitations, in order that humankind move away from perfection mimicry attempts. Considering these arguments, in Digital-analogic hybrid practice, the artisan's skill and vision are key points to the fabrication process, which is enabled by new technologies being used as tools for creative process freedom, traditional

[1] Available at: https://www.instructables.com/. Accessed on Apr., 13th. 2025.
[2] Available at: https://www.thingiverse.com/. Accessed on Apr., 13th. 2025.
[3] Available at: https://makerworld.com/pt. Accessed on Apr., 13th, 2025.

aesthetics experiences, and physical limitations presented by the materials (Johnston, 2017).

A technology's adaptation to its user limitations is deeply related to what McCullough (1996) describes as the equilibrium between affordances - the possibilities found in a respective environment, and the constraints - the respect to the material and the shape. To the author, mankind's actions must be mediated in order to the work to acquire substance, this mediation can occur through a material, a tool or other agents. Usually, the medium receives the tool action, and the resulting substance mediates the action in conforming and communication terms, since the medium influences the way the tool conducts the author's intent. When tools are complexified, as in the digital fabrication case, it’s hard to ascertain where the tools end and the medium starts. Thus, the best way to understand the medium is to explore the amplitude of their possibilities through direct involvement.

It’s in this train of thought that Tavares (2019) argues that the creative practice in digital handmade isn’t pursuing the shape in itself, but an experimental continuum. Since parametric archive in CAD systems and digital fabrication materials are iterative, it is possible to practice an experimental activity that may be incorporated in post-production stages (Tavares, 2019), beyond focusing on projectual data and parameters alteration. The author advocates that these processes conducts to non-predictable and non-determined shapes where the designer practice “lives harmoniously with the dialectic between: individual-collective; allography-autography; risk-certainty; digital handmade” (2019, p. 26).

2.3 THE MERGE BETWEEN LOW AND HIGH-TEHC: DIY MATERIALS

A strategy that unifies digital to handmade is the DIY Materials approach. For Rognoli et al. (2015, p. 693) those are “made by self-fabrication experiences, either individual or collective, made by techniques and processes invented by the designers themselves as a result of a handmade material process”. Therefore, the practice combines personal fabrication, craftsmanship and digital fabrication (Garcia; Rognoli; Karana, 2017) through bottom-up innovations that allows quick, local sourced experimentation (Vuylksteke et al., 2022) and quick access material fonts (Rognoli; Garcia, 2018).

The productive process for such materials is a constant iteration via trial-error methods, where the designer turns into a craftsman that creates its own materials and tools for their manipulation (Rognoli et al., 2015). This fact shows the viability of conducting research on materials and their application under DIY techniques as well as the use of open access platforms, according to Rognoli and Garcia. This makes clear the relationship between design and technology. The process also works alongside the experimental continuum we discussed above, where the medium is the DIY material to be developed and experimented upon.

Sörensen and Thyni (2020) points out that those processes derive from matters such as culinary sciences, arts and craftsmanship, executed either by low or no tech tools. Rognoli and Garcia (2018) states that a designer can experiment with materials in their kitchen from a recipe they found on-line or purchase open code tools to improve upon the already developed material. This reflects the “think globally, fabricate locally” from Gershenfeld (2012).

The results of such processes usually express transdisciplinary aesthetics that show the existence of a manual work (Rognoli et al., 2015). In this sense, it’s common that they are taken as low technology and imperfect appearance material, since our material experience is affected and defined by industrial utilized materials from mass-producted objects with which we frequently have contact (Rognoli; Garcia, 2018; Sörensen; Thyni, 2020). In the other hand, this emerging practice contributes with the creation of alternative and sustainable materials through new material, non-conventional, experiences (Sörensen; Thyni, 2020). Alongside, Rognoli, Garcia and Pollini (2021) states that this approach stimulates designers to consider the systemic and global thinking considering alternatives that works with Circular Economy.

2.4 FABRICADEMY: DIGITAL HANDMADE IN FASHION

Gradually, fashion finds its space in fab labs and makerspaces, which originated the so-called Fashion Labs, or Textile Labs. Those names express the integration between digital fabrication spaces and the fashion-making (Silva, 2019) based on big industry decentralization phenomena (Felippe et al.m 2020). In the labs, apart from digital fabrication machinery, it's usual to find sewing machines and other equipment for clothes making.

For Perez (2018), these labs foster knowledge trade and collaboration among users, designers, producers and seamstresses. Beyond that, being understood as experimentation spaces for digital handmade in fashion (with Handmade related to DIY materials) the fashion labs are set as fertile grounds for the hybrid practices. In this sense (as stated by Silva) fashion labs sometimes merge “high-tech processes to manual processes, for example: the natural dyeing workshops” (2019, p. 36).

An example that integrates the fashion labs concept to personal biomaterial fabrication is Fabricademy, an workshop network and a multidisciplinary intensive program, the Textile and Technology Academy. Lasting six months, the program explores the intersection of digital fabrication, textiles and biology under the “doing-learning” methodology. This course is promoted by Fab Foundation, an organization created in 2009 to ease the operation and support the Fab Labs network around the globe (Fab Foundation, 2025). Furthermore, it is part of the Academy initiative, which was promoted by the same organization, it fosters the learning about the use for the spaces and shares the practical teaching model to students in working groups with local mentors, globally connected via content sharing platforms and interactive on-line classes with global speakers (Fabricademy, 2025).

Actually, the course is present all around the world in a fashion labs network connected through the internet. The labs are located in Asia, the three Americas, Middle East, Africa and Europe - the last harboring the most labs. Still, it is possible to take the formation without a nearby Fabricademy lab through on-line mentorship and access to other workshops with digital fabrication technologies available.

According to Thomas et al. (2024) study, in the course the students are encouraged to document their weekly performances in open personal platforms about their future roles on sustainability transition. The authors also points out that the program allows the opportunity to democratize the digital handmade and foment the technological alphabetization, working outside formal educational ecosystems, be them governmental or business related.

Apart from that, the intensive and multidisciplinary learnership that is offered brings forward “multipotential” subjects, moved by curiosity and willing to explore new fields in order to develop their own professional trajectories (Thomas et al., 2024). This reflects upon the course conclusion projects that verses upon areas like assistive tech, health, wearables, art, regenerative economy, recycling and upcycling, biofabrication, material sciences and fashion design (Thomas et al., 2024). In doing so, professionals that graduate through the program can follow up as digital craftsmen, high-tech fashion designers, fab labs managers, material developers, interactive performers among other professions (Fabricademy, 2025).

3. METHODOLOGY

The methods used were: Narrative Bibliographic Review (Ferrari, 2015), for the themes and contents contextualization, together with a Documental Research. For Sá-Silva, Almeida and Guiani, the second is a “procedure that uses methods and techniques to apprehend, comprehend and analyze documents from the most varied kinds” (2009, p. 5). Therefore, this method differs from bibliographical research when dealing with primary sourcers, or, in other words, documents that didn’t receive analytical treatment (Sá-Silva; Almeida; Guiani, 2009).

According to Gil (1989) in Documental Research, the content analysis occurs in three phases: 1. Pre-Analysis: An organization phase, the first contact with the documents using a fluctuating reading technique, followed by the selection of documents and the preparation of the material for the analysis; 2. Material exploration - codification, ordination and classification of data; and 3. Data treatment, inferences and interpretation.

In the first phase, the documents selected were the final projects in Fabricademy website, those were related to the merge of fashion, biomaterials and digital fabrication from the last two years of the course (semesters from 2022/2023 and 2023/2024). Works about hardware development, natural dyeing textile materials and service propositions were excluded. The selected works, apart from the three main subjects presented here, should contain a detailed documentation about inputs, manipulation processes and final products.

Above that, the questions made to the analysis of documents were: Which inputs and fabrication processes were used in DIY materials obtention? Which Processes, tools and technologies were used for the manipulation of such materials in digital fabrication at the Fab Labs spaces? Which opportunities and strategies were engaged for the biomaterials used in fashion under digital fabrication? The selected projects were: 1. Barbara Rakovská - Amber Grain Embroidery: Growing folklore elements; 2. Viviane Labelle - Interference; 3. Olivia Cueva - FLUUUID: Fashion Design for Impermanence; and 4. Emma Picanyol - M.

In the second phase, concerning material exploration, the documents content was classified in the following categories: a) about the project; b) DIY material used, inputs, processing and post-processing; c) fashion products obtained; and d) digital fabrication technologies implemented as well as realized processes. In the end, in data treatment, inference and interpretation, the data was tabulated to content summarization.

4. RESULTS AND DISCUSSION

This session will present the results obtained after the selected projects analysis.

4.1. Barbara Rakovská - Amber Grain Embroidery: growing folklore elements

The project explores the fabrication of root-based materials, through a biodesign approach that uses non-human living beings in their processes and product or system projects. The final products are inspired by traditional garments from Slovak and Czech folklore, symbolizing the importance of grain as a vital source of sustenance and material wealth for the region.

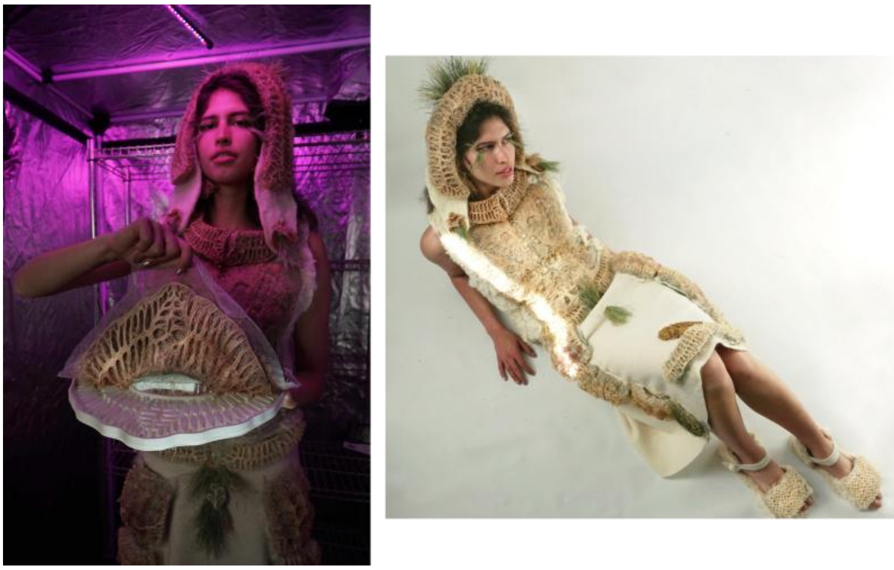
The main materials used were domesticated wheat and barley grass roots. As production inputs brown lentil grains, alfalfa, dry areas grass seeds, beans, black beans, cranberry and radish were used. Root domestication involved controlled indoor cultivation in different media (coconut powder; agar agar; felted wool residue; mixture of vegetal compound, wood fiber, pine bark, and earthworm humus). For the germination, the inputs were submerged in a water and vinegar solution for 30 minutes and then germinated in water before subtract insertion. For the separation of leaves and roots, a viscose fabric was used.

As post-processing, the material underwent dehydration in the oven at 60º, some materials were plasticized by immersing in a vegetable glycerin solution for 12 hours. Some roots were dyed with natural pigments and mica powder. For laser cutting, they were hot pressed and some were coated with sodium alginate bioplastic. Some roots have also been spun or moulage shaped.

The digital fabrication technologies used were Laser Cutting and 3D Printing of PLA molds for cultivation. The parametric pattern of this piece used the LLOYD'S algorithm in the Grasshopper extension of the Rhinoceros program.

The final pieces are: a skirt, cuba (traditional Slovak coat), sandal and crown. The final patterns represent the embroidery and lace of traditional costumes. Figure 1. shows the final parts of the project.

FIGURE 1 - FINAL PRODUCTS MADE FROM ROOT DOMESTICATION.



FONT: Rakovská (2024).

It was observed that the proposal merges the artisanal to digital by proposing the manufacture of traditional folkloric costumes through digital fabrication techniques, expanding its power by employing algorithmic modeling for root domestication - a unique albeit replicable process. In addition, the choice of handmade post-processing techniques, such as natural dyeing, manual spinning and moulage modeling, reinforces the hybrid character of the project. Such processes transcend the use of digital fabrication and, as Johnston (2017) points out, exemplify, both visually and projectally, the new aesthetics that define the digital handmade. These characteristics also indicate new projectual possibilities, especially in regard to more sustainable ways of doing things.

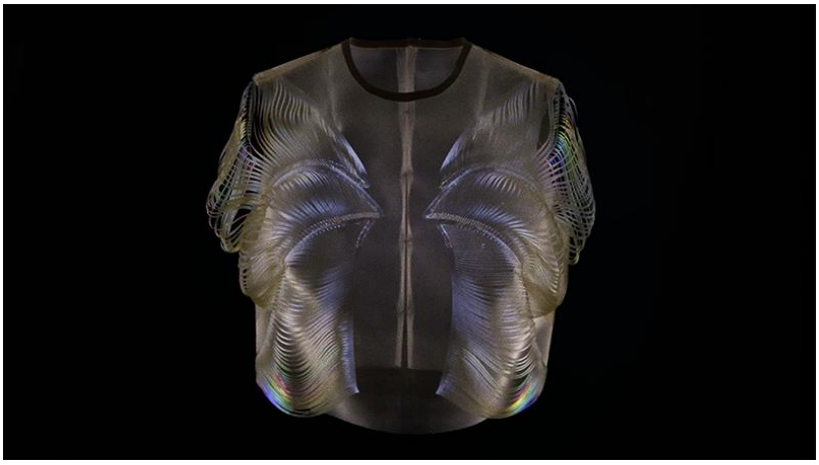
4.2. Viviane Labelle - Interference

Interference explores the intersection between biofabrication, computational design and moulage, inspired by the visual aspects of squid and kirigami (Japanese three-dimensional folding). For this, it uses a combination of biofabricated gelatin-based plastics and polarized light.

The DIY material used was water-based bioplastic, gelatin and glycerin. For the formulation, it followed previous recipes developed by former students of the program. Percentage tests of the inputs and thicknesses molded in acrylic sheets were performed. Depending on the thickness of the material and its composition, the drying time was 1 to 7 days. In this process, the designer recommends removing the material from the mold when it is dry. It is also observed that less glycerin creates a stiffer material and more glycerin creates a softer material. Tests of the correlation between translucent material thickness and color under polarized light were performed at the same time. The final bioplastic sheet was poured onto a table lined with an unspecified material, the edges were delimited with silver tape. As post-processing, tests were performed with unspecified gloss and matt finish.

Regarding the digital fabrication technologies used, the geometric pattern was downloaded from an open-file from Github and changed in the Rhinoceros' Grasshopper extension. At this moment, tests were performed considering spacing between the lines, length of the lines, orientation and general blending of the lines. Subsequently, the files were laser cut. Due to the resulting poor quality (gelatin is heat sensitive), the final piece was cut into the Vinyl Plotter using multiple cutting steps. For this stage, the material was laminated onto an adhesive mat and secured with tape at the edges. It is recommended that the material is of regular thickness. The final piece is a t-shirt with hand-sewn moulage bioplastic details under a polyester mesh, as illustrated in figure 2.

FIGURE 2 - FINAL PRODUCT UNDER POLARIZED LIGHT.



FONT: Labelle (2024).

In this project, the option to use open files in online repositories reinforces the collaborative and open practice that is characteristic to the maker community, as discussed by Rognoli et al. (2015), Kohtala (2018), Eckhardt et al. (2021), and Von Platen and Kitani (2023). This approach is also present in fashion labs, as described by Perez (2018), and in the practice of DIY materials, according to Rognoli and Garcia (2018). It is evident that such files and formulations available on-line are contextually adapted to the project, either by adjusting the glycerin proportions - in order to increase the flexibility of the material - or by adapting the digital files to the specific configurations of the proposal. The experimental continuum described in the literature becomes evident in the tests carried out with different thicknesses and formulations, as well as in the reapplication of the same file in different fabrication technologies. In addition, the use of polarized light dialogues with the reflections of Felippe et al. (2020) on new forms of appropriation of Fab Lab spaces by fashion.

4.3. Olivia Cueva: FLUUUID - Fashion Designed For Impermanence

This project is a response to fast fashion and its encouragement of throwaway culture. It consists of a set of naturally dyed bioplastic clothing, shoes and accessories designed for minimal use and subsequent composting.

Gelatin bioplastic was used, with variations in consistency and colors made with natural dyeing. As inputs for coloring cochineal, turmeric, food dyes of various colors, white tea, eucalyptus, activated charcoal, onion peels, spirulina and red cabbage were used. To change the color variation cream of tartar, alum, lemon, vinegar and sodium bicarbonate were used as pH modifiers. In addition, some tests also contained ethanol and lavender essential oil to prevent bubbles in the material.

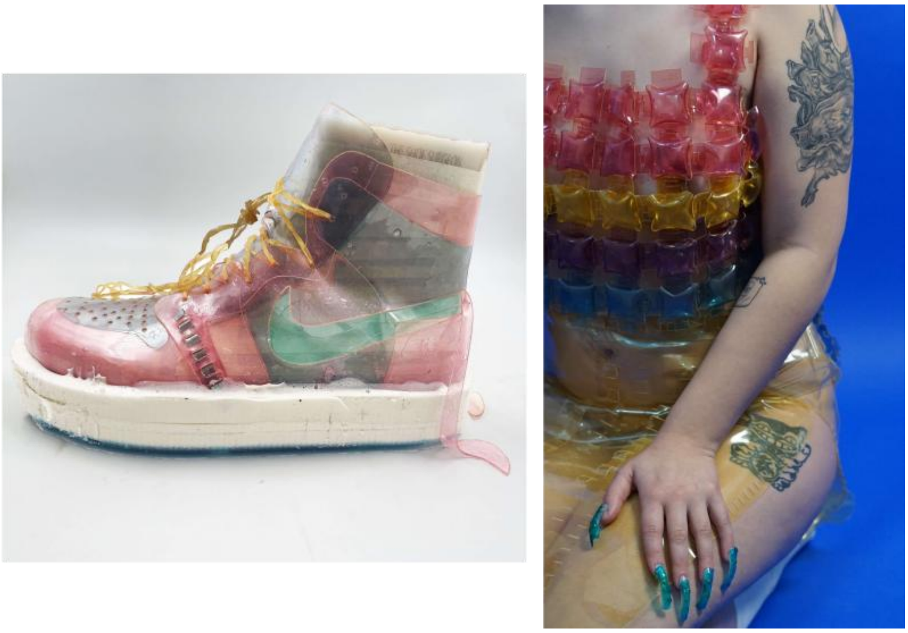
Fabrication consisted of baking and molding on a non-porous surface (plastic molded with the desired pattern and glass) with a wooden edge (in order to avoid shrinkage). About this process, the designer does not recommend molding gelatin biomaterials into glass. For molding, the surface was leveled to ensure a uniform material and the environment was sterilized to avoid contamination. In addition, the molding of the bioplastic under a textured plastic sheet was inspired by the documentation of a former student.

The samples dried for 3 to 5 days at room temperature, while the large leaves required a minimum of one week. Like the previous project, the designer recommends demolding the materials only after drying so as not to contaminate and undergo a shrinking process, as well as to prevent the circulation of people around. In addition, it is not recommended to demold the materials too late, at the risk of becoming rigid and stick to the mold. To avoid bubbles and foams, these were removed with a metal spoon in the pan before placing the mixture in the mold.

The final pieces were laser cut. The top was composed of modules and all pieces were made with interlocking, dispensing with the sewing process. The modules placing pattern was designed in Rhinoceros and used the locking system documented by a former student of the course. The sole of the biofoam shoe was made in a CNC Router machined mold.

The joining of the parts was done with the aid of a thermal blower. For this process, the designer does not recommend using the melted material itself as glue. Finally, the final collection included a top, skirt, sandals, sneakers and false nails that can be seen in figure 3 below.

FIGURE 3 -FINAL PRODUCTS IN GELATIN-BASED BIOPLASTIC



FONT: Cueva (2023).

This project proposition dialogues with Sennett's (2009) reflection upon machine adaptation to human-kind limits. In Fluuuid, the designer recognizes planetary limitations and the unsustainability of fast fashion model propagation on current standards, recurring to digital fabrication in order to conform artisanal materials that are water-soluble and, as such, ephemeral in their utility just as the fast fashion trends. In this making, the proposal configures itself as a new, non-conventional, material experience, as pointed out by Sörensen e Thyni (2020).

4.4. Emma Picanyol - M.

"M" is a brand of purses made with corn husks, agricultural waste from the Catalan winter season-based materials. The project proposes efficient fabrication through molding techniques and contemporary aesthetics of sustainable craftsmanship.

The documentation presents an extensive research of biomaterials fabrication based on corn husk, using different ingredients and techniques. Thus, it was possible to identify a wide range of inputs. The ones used in the formulation of the final bags were: pine resin, dried corn husks, green clay, carnauba wax, alcohol, glycerin and eggshell powder. However, the tests also used alginate, calcium chloride, sodium carbonate, casein (made with milk and vinegar), olive oil, apple leather, corn starch, talc and CMC (carboxymethylcellulose).

The manufacture of the materials began with the processing of the shells to break down the fibers and dissolve non-cellulosic materials (such as lignins and waxes). First, they were boiled in a sodium carbonate water solution for 3 hours. After being rinsed and dried, they were crushed in a plastic grinder and boiled with sodium carbonate for another 3 hours, followed by another rinse. Subsequently, they were strained. The pate resulting from this step was dehydrated at 105 degrees in order to obtain the DMC (dry material content). The dry content was grounded in a mixer.

The resulting powder was used for filling in sodium alginate-based formulations of the Materiom open collection, due to its waterproof properties, texture and properties similar to leather, easily moldable, high resistance, in addition to being biobased and compostable. Here, other inputs were also tested.

The designer also fabricated paper based on the powder she obtained for the packaging of the bags. In this step, the DMC was mixed with hot water and manipulated with molds for the manufacture of handmade paper. Grass seeds were placed in the mixture for the material to be planted by the end customer.

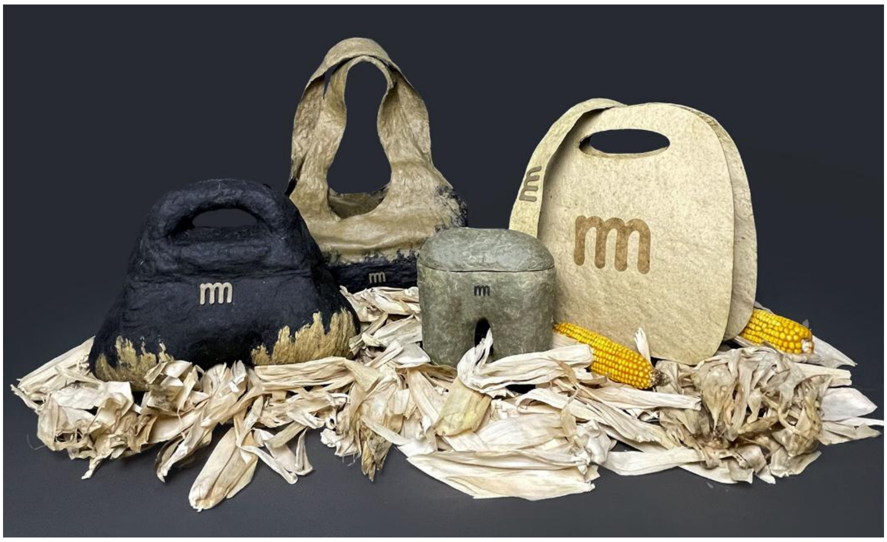
Additionally, a CMC leather was produced, combined with starch, glycerin, fiber pulp, vinegar and water, with variations in proportions and addition of other ingredients, such as talc, clay and carnauba wax. Here, the formulation was cold blended and showed advantages such as the formation of a bio glue and fire resistance. The processes for obtaining pine resin-based composites involved cooking the inputs. The recommendation is not to breathe the vapors resulting from this cooking.

The post-processing techniques were: carding for 30 minutes (process that detangles the fibers) and manual spinning; manual braiding; felting; natural dyeing with activated carbon and submersion in glycerin to give flexibility to the material. To make the material waterproof, a thick layer of tung oil was applied with a brush to the surface. Other endings that Emma has not tested, but suggests for further experimentation, are the use of chitosan, shellac and hemp oil.

Regarding digital technologies, the files were made in the Rhinoceros program.

The final bags were produced in foam machined molds (SOPRA-XPS) on the CNC router. She also suggests printing the formwork on the 3D printer with hips or PVA and then dissolving it, to make parts that do not need joining. 3D printing for the creation of silicone molds for small parts was also done. The materials were also cut and laser engraved (packaging and details). The final result is shown in figure 4.

FIGURE 4 - CORN HUSK-BASED PURSES AND PACKAGES.



FONT: Picanyol (2023).

In this project, the experimental continuum manifests itself again, showing the exchange between hand and machine both in the molds explored through mixed digital fabrication technologies and in the variety of inputs — many of them waste — tested in different formulations. The conscious choice of materials and molds, in the face of countless possibilities, reflects respect for matter and form, as discussed by McCullough (1996). In addition, the predominance of the use of local agricultural waste reaffirms the principle of thinking locally, proposed by Gershenfeld (2012), and constitutes a practical example of the incorporation of sustainability in DIY material approaches, according to Rognoli, Garcia and Polini (2021).

4.5. Data Tabulation

To summarize the information, the data were tabulated in relation to the inputs for DIY materials formulations as indicated in the projects, handling processes, future recommendations, fashion products obtained, digital manufacturing technologies used and their purposes.

TABLE 1 - MAIN RESULTS OF THE DICUMENTAL RESEARCH

Criteria	Data Obtained
Inputs for DIY materials	**Grains and seeds**: brown lentils, alfalfa, beans, black beans, cranberries, and dry areas grass seeds; **residues and fibers**: felted wool residue; dried corn husk; **Liquids**: water, glycerin, vinegar, and alcohol; **Waxes and oils**: olive oil, lavender essential oil, pine resin, carnauba wax, Thung oil; **Biopolymers**: gelatin, sodium alginate, corn starch, CMC, casein (made with milk and lemon); **Natural pigments**: cochineal, turmeric, food dyes, white tea, eucalyptus, activated charcoal, onion husks, spirulina, mica powder, and purple cabbage; **pH modifiers for natural dyeing**: tartar cream, alum, lemon, vinegar, and sodium bicarbonate; **Other materials**: dehydrated corn husk powder; green clay, mica powder, eggshell powder, calcium chloride (for curing alginate bioplastic), sodium carbonate, apple leather, and radish
Processes for handling DIY materials	**to obtain DIY materials**: root domestication, cooking, mixing in mixer, manufacture of handmade paper; **for post-processing of the materials obtained**: rinsing, curing, dehydration, glycerin immersion, natural dyeing, hot pressing, spinning, weaving, carding, felting, modeling, moulage, hot joining.
Processes carried out with digital fabrication technologies	**CNC router:** mold machining, biocomposite machining; **3D printing:** small and large mold printing; **Laser cutting:** bioplastics cutting; **Vinyl plotter:** bioplastics cutting.
Final Products	**Clothing:** skirts, blouses, t-shirts, scarves; **accessories:** purses, crown, false nails; **shoes:** sandals, sneakers; **others:** packaging

FONT: the authors (2025).

This mapping allows us to visualize the interconnection strategies between Fashion Design, Digital Manufacturing and DIY Materials.

During the analyzes, it was observed that, unlike the conventional process in fashion design, the design of materials happens before the products. This is consistent with the methodological approach proposed by Karana (2015), Material Driven Design (MDD). The choice of an input and/or base formulation for subsequent changes with respect to percentages, additions, thicknesses and other handling characteristics is frequent. Only after such specifications does the product design happen. This would correspond to the first stage of the MDD, where an intimacy with the material and its possibilities is mapped and created (Karana, 2015). It was possible to observe this pattern in all documentation. In the **Amber Grain Embroidery** project, this was observed in the study with different grains, seeds and cultivation media. In the **Interference** project, in changing the percentages of bioplastic inputs and thicknesses tested. In **Fluuid**, the changes made mainly concerned the research of colors with natural pigments and the type of mold used. Lastly, in **M**, this was observed in the wide range of samples of resulting materials, through the variation of formulations using corn husk.

Ultimately, the projects followed the dynamics of trial and error, with aspirations to sustainability, biodesign and connection to art. This is materialized in the final aesthetics of the products, which emerge as visual results of continuous experimentation with digital inputs and technologies through applied research and show an entanglement between hand and machine. Thus, personal comments in the documentation about expectations and frustrations in relation to the experiments experienced are common, contributing to the exchange of knowledge and replication of the processes in a more human and transparent way. An example is the frequent difficulty in joining parts of DIY materials. Still, everything is recorded in order to optimize the processes in future replications. This principle of sharing adheres to the philosophy of Fab Labs, defended as “zones of free experimentation” by Kohtala (2018).

Digital technologies are repeatedly used for mold making and material cutting. In addition to these, in project **M**, they were applied for the conformation of the DIY material when machining it, and for laser engraving finish. This combination expands the possibilities in product development and goes against closed material development systems, as advocated by Rognoli and Garcia (2018). It was observed that as students experimented, their interest in exploring new approaches increased.

The participants cited previous documentation of final Fabricademy projects or open collections for online consultation that helped them, reiterating the point of Thomas et al. (2024) regarding the frequent peer exchange in the course. This favors the quality of the materials developed and final products, as well as the experience as a designer. However, the predominance of using the Rhinoceros software with the Grasshopper extension for parametric design was noticed, which may hinder the future replication of parts of the project for being paid.

5. CONCLUSIONS

The analysis observed that the combination of DIY materials with digital fabrication technologies can result in products with a strong authorial character, based on guiding principles and environmentally sustainable values, either by the inputs used - biodegradable or derived from organic waste - or processes carried out that emphasize handmade work. These practices add value to the technologies presented here by adding manuality to digital and favour reproducibility in a systemic but unique way. Thus, the examples presented here go against the grain of today's fashion industry and contribute to the prospect of a possible future.

In the academic context, the documentation helps to disseminate these practices in Fab Labs and experimentation spaces, encouraging new approaches in fashion design, once raw materials, tools and processes have been described and summarized, based on real cases. For this, the documental research method combined with the literature review proved to be effective in enabling the comparison between data extracted directly from the source (designer authors) and consolidated academic knowledge.

The complexity of the cases studied provided a significant view of these practices in Fab Labs and Fashion Labs. Still, the scope of 4 projects offers a limited cut. For future studies, it is suggested to analyze a broader set of projects, considering designers of authorial fashion who work with emerging material and digital technologies. This can contribute to the exchange of knowledge between academia and the market. In addition, it is recommended to incorporate new analysis criteria, such as perceived socio-environmental strategies.

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