

Material research in the design field: a gender gap analysis

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Abstract. Within the framework of technology, design and material production are profoundly influenced by the class relations of production. Artifacts and objects are no longer seen as separate from society, but as part of the social matter that regulates and holds the society together. The development and use of materials are also closely connected to the social systems in which they operate. To date we have few empirical observations in this regard, especially on the investigation of the female presence in the discourse of material design. The connection between material research and gender has recently become an issue of social and technological relevance, as there is a lack of data on women activity. In addition, the communicative aspect of the material design approach will be analysed through forms of social constructivism, which foresees people working together constructing artifacts, and their potential to enhance the perception of matter in its forthcoming dimension. This contribution aims to investigate the approaches of women designers to the innovation of materials. It will start from an historical perspective via figures such as the Italian architect Anna Castelli Ferrieri up to the new generations of women designers and researchers who consider specific factors for each study and observation, applying what is called the “clinical approach”. We will encompass selected examples of good practices of social sustainability through the inclusion of women in the field of material research and production. In addition, we consider the profound impact of contemporary good design practices, questioning what impact they have on social life and the environment, due to the relationships with our artifacts and habitat under the climate crisis. Overall, we propose that gender issues are finally embedded in the design discourse and some results are emerging.

Keywords: expanded design / gender gap / Anna Castelli Ferrieri / material design / sustainability / communication

1 Introduction: from expanded design to material design. Artifacts in social life

Design culture and research embrace technical and humanistic cultures: deeply entangled with society and all that it concerns. They regard not only production and processes but also human networks and cultural layers. Design history is key to better understanding social processes, and design culture found new fields of application outside the realm of design practice and design education [1]. As Beatriz Colomina and Mark Wigley state, design has gone viral [2], touching multiple layers of the intimate relationship between humans and design through history, affecting not just our way of living, interacting, and evolving but also strongly shaping our habitat.

Philosophers, anthropologists, and sociologists have investigated this phenomenon by embedding design in systemic global issues such as environmental concerns, human and non-human exploitation, and wealth polar-

isation [3–5]. The fundamental sedimentation of post-structuralism and post-modern theories of the second half of last century has generated a collective and active response in the design system of nowadays [6,7]. If earlier designers were interpreters of social needs in a broad sense, today, the trajectory towards co-design sees designers allied to social activism. Sustainability (social, economic, and environmental), cleaner technologies and materials [8] are the focus of a new transdisciplinary engagement between design and other disciplines such as art, biology, chemistry, STEM, social sciences, and geopolitics. Such a transdisciplinary approach has triggered what is now a common practice: design activism as a possible response to the threat that production/consumption/waste is causing to our social and eco-system [9]. In the environmental emergency, caused by anthropic actions, it becomes imperative to adopt a significant change of approach in the relationship between mankind, artifacts, and the environment. Buildings, artifacts, materials, tools and works of art should be considered as living entities as they are subject to transformation, dispersion, and consumption, giving matter due recognition as an active participant

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in the evolution of the world [4,10]. Quoting sociologist Tim Dant [3]: “Culture is not mediated simply through messages in linguistic or quasi-linguistic forms, it is also distributed through the artifacts that shape everyone’s actions in late modern societies”. Contexts, politics, cultural development, and intersectionality¹ thus become spheres of action for design in society [11,12]. In this framework, design has gradually expanded from objects to materials, thanks to the fact that it is based on communicative and relational competences, capable of connecting different needs such as industrial production, material consumption, environment, and resources. Artifacts and materials design finds nowadays a key role in the research and investigation of their agency in our habitat, in our social life and actions [5,13,14].

Material design is a process. An advanced vision extends its object to the “social modelling” of form, use, and technical systems [15]. This process is conceivable in a social constructivist key: the design material experience is generated within a process of social, cultural, and economic mediation that has at its centre the negotiation between groups of actors in the processes of materialisation of factual art. This process is clinical, which makes the design activity and the design material dependent on the actual circumstances in which they develop, making each specific design action unique and, at the same time, rebuildable with a recorded method [16]. If Stefano Maffei points to this approach in the organisational perspective of design, Jeffrey Sachs does it in the field of economics, looking for a new system of analysis – inspired by his paediatrician wife – capable of including as many factors as possible for the individuation of what the real problem is.

“A new kind of development economics needs to emerge, one that is better grounded in science – a ‘clinical economics’ akin to modern medicine. Today’s medical professionals understand that diseases result from a vast array of interacting factors and conditions: pathogens, nutrition, environment, aging, individual and population genetics, as well as lifestyle. They also know that one key for proper treatments is the ability to make an individual diagnosis of the source of the illness. Likewise, development economists need better diagnostic skills to recognize that economic pathologies have a wide variety of causes, including many outside the traditional ken of economic practice” [17].

Through the clinical approach, the design material experience originated within a process of social mediation and, among many other factors we shall also include the theme of gender and particularly the feminine presence in the material design discourse.

The intent of this paper is to advance the study of the women designers’ contribution to design-driven materials innovation. In terms of profession and research, compared to engineering and hard sciences, design is certainly a more gender-inclusive field thanks to its creative and domestic

sides, stereotypes notoriously associated with the feminine area (or within the feminist area). As Elizabeth Pollitzer stated:

“Achieving gender balance in participation is not just a matter of social justice. Research has shown that the benefit of more equal participation is improved collective intelligence, cognitive diversity in problem solving, and more realistic understanding of context, all of which help make research and innovation both relevant and responsible to society” [18].

2 Methodology and case studies

As regards the methodology, to avoid the risk of distorting the analysis of actual phenomena – that can come by ignoring historical process – we start our analysis with an incursion in the creative modalities attributed to women and the historical perspective of women activity in the design field. We first introduce the figures of Bauhaus’ women designers and their interaction with the creative environment of the school and its notorious professors. Therefore, we will focus on the Italian architect and designer Anna Castelli Ferrieri (1918–2006). This last was one of the first women who dealt with material design, working with a futuristic material, as plastic was at her time, and in close collaboration with the industry. She moved outside the confines of craft and traditional materials such as textile, to which women have been relegated for a long time. Then we put in relation her work with the current material design approach. We take into account a new generation of female material designers who work analysing specific material contexts considering as much as possible the phenomenon situation with unique characteristics and with a recorded method [16]. This is what we call the clinical approach. We encompass the situation of women’s activity in the material design world with data and cases studies. In that way, we aim to contribute to the understanding of the current phenomenon as the result of gradual women’s empowerment in the design field, by regarding it as a part of a century-long process that is yet not complete [19].

The aim of this paper is to identify good practices of social sustainability through the inclusion of women in the field of material research because they provide a variety of approaches. Women bring a feminine vision that is diverse and complementary to the predominant white cisgender² male vision, and this enhances a material design oriented in an inclusive way, resulting in making an innovative contribution. Starting from this concept, women have always played a significant role in every design field. This means that it is a question of gender, but never in a univocal direction, or worse in a stereotyped way. Each one has his/her/they own sensibility and approach. Only the resultant combination of all these sensibilities could bring a socially

¹ Network of connections between social categories such as race, class and gender, especially when this may result in additional disadvantage or discrimination.

² Designated person whose sense of personal identity and gender corresponds to his or her sex at birth.

sustainable way, which supposes a wider material design perspective including all the specifications that the gender spectrum can encompass.

3 Historical perspective: women's creative modalities

In history, women have been active agents of production in different cultures, sectors of activity, techniques, labour, and environments, even if not written in all history books. The pseudo-inclusion of women in the design profession is a recent conquest of the first half of the 20th century.

The nuanced women's path has been characterised by times of acceleration and deceleration towards modernity. Women's participation in the public sphere as makers or consumers is considered as an acceleration. In contrast, the segregation of production to the private space is seen as a deceleration, often connected to ideological movements against modernity. Women have introduced specific creative modalities in their artistic approach, and achieved a soft mastery characterised by soft skills of negotiation, compromise, and give-and-take as psychological virtues [20]. Women's creative modalities create a space for mutual support and trace a path towards an inclusive society, which is more democratic, respectful of diversity, and is founded on diverse production perspectives where all voices are heard. The creative approach and soft mastery are fundamental to complement hard skills to manage complexity [21].

4 Historical perspective: the role of women as studied by the history of design

In 1986, design historian Cheryl Buckley published her *Made in patriarchy: towards a feminist analysis of women and design* with four key propositions. These argued how feminine figures were put aside in the design panorama of the 20th century and mostly in the design storytelling [22]. She claimed that even though women had interacted with design in numerous ways, they were largely ignored. When women's involvement with design was acknowledged, it was within the context of patriarchy and its social consent. When involved in projects, women were categorised: they had sex specific and stereotyped skills such as feminine, natural, decorative, and instinctive. In parallel, in that environment, the only accepted vision of design was related with a commitment to modernism, focusing on technology's progress and on the production/consumption system in society. In this framework, the figure of the designer was perceived as the creator who played a role in the history of pioneering individuals, with the idea that the meaning of design resided in its "author's" intentions, and this figure could have been only cisgender male [23]. The professional environments dominated by men have severely tested the ability of women to make autonomous choices, centred on the awareness of their own individuality and the strength of their thinking.

Historical research has not yet succeeded in giving a precise and objective definition of the women's contribution to the development of the design discipline, nor in favouring a social construction of the feminine and its methods. However, in recent decades a lot of work has been done by historians to advance towards this goal [24]. In addition to an evident historiographical question, the cultural and socio-economic factors of the contexts in which women have operated conditioned the paths of individuals, even in those fields in which women have been allowed active participation, as in the case of teaching and artistic contexts. In these two latter fields, unlike the business and the entrepreneurship, there has been no shortage of female figures, albeit concentrated in the humanities rather than in the technical-scientific ones. Still in the 2017/2018 academic year in Italy, a peak was recorded in the "humanities and arts" area (77.6%), traditionally chosen by female students, while their presence decreased in more scientific or technical fields, reaching the lowest levels in the "agricultural and veterinary" area sciences (48.1%) and above all in the "engineering and technology" area (27.4%) [25].

Even within the framework of one of the most progressive schools of the 20th century, such as the Bauhaus, which set out to be a revolutionary laboratory, there was unequal recognition of women's contributions, as highlighted by the latest study conducted by Anty Pansera [26]. Her recent book *494 female Bauhaus* is dedicated to the female Bauhaus' figures: 475 female students, eleven female teachers, 1 female manager, 1 female photographer, 6 women around Walter Gropius—who have remained largely unknown—during its 14 years of existence, from Weimar, to Dessau, to Berlin. Through documents and testimonies, the study shatters the inclusive myth of Bauhaus that instead proves to be a lost opportunity as an example of a culture still inherently conditioned by sexism and gender bias. In fact, these students were "induced" by the *Meisterrat* (the Council of Masters) to enroll above all in the textile (Fig. 1) and ceramics workshop, which was considered more "suitable" for women. This advice hindered women's access to the architecture course, to which many of them would have aspired instead [27].

Among them, only two became teachers in the same school: Anni Albers, loom artist and Marianne Brandt, teacher of metals. The latter, after the *Vorkurs*, was able to attend the Metal Workshop thanks to the intercession of Laszlo Moholy-Nagy, who appreciated her great creativity and remarkable technical expertise. However, Brandt was forced into a fire pit, opposed by colleagues who shared Gropius' machismo. "She is the one who designed some of the most iconic pieces associated with the Bauhaus [...] household objects in simple and essential shapes [...] characterized by the combination of different materials [...] are testimony, even if handmade, of a new aesthetic aimed at industrial production". In 1928 Marianne Brandt was even called to replace Moholy-Nagy in teaching and in the direction of the Metals workshop. Even more, Gropius then requested her collaboration in some of his personal furniture and interior design projects.



Fig. 1. Students of the Textile workshop, directed by Gunta Stözl, (born Adelgunde) at the Bauhaus Dessau school from 1926 to 1931. Photo of around 1927 (image credit: Alliance/AKG Images).

5 Historical perspective: material design through the case of Anna Castelli Ferrieri

Anna Castelli Ferrieri (Fig. 2) as a designer and President as the unique woman of ADI, *Associazione per il Disegno Industriale* in the 1960s, is an example of a woman who strongly influenced the Italian design culture and the research of materials in Italy and abroad. She combined all the precepts on the condition of women in the design panorama at that time. Compared to her Bauhaus colleagues, she worked with brand-new materials such as synthetic polymers and maintained her own independence while collaborating with other male colleagues, like Ignazio Gardella and even her husband Giulio Castelli for Kartell [28]. Anna Castelli Ferrieri's example is worthy of analysis in this context of gender and material design because she was one of the very few women that approached design from the material perspective with a clinical approach at that time.

In terms of feminine skills in design discipline and material design, she had a completely different vision from the decorative and natural ones:

“The most important thrust that determined the choices in my life was the desire to communicate. So, I chose architecture, because it seemed to me that the most intense way of communicating was to think and implement projects that were then inhabited and used and transformed and reinvented by others. I have always believed that the first essential step of this path was to verify the validity of my thinking in the concrete, physical realisation of the work. A project becomes



Fig. 2. Anna Castelli Ferrieri photographed by Ornella Scancassi with her seat installation 4870 in 1987. The seats are in polypropylene, injection moulded. The seat won the Compasso d'Oro ADI in 1987. Kartell 1985—in production (image from Morozzi, p. 23 [28]).



Fig. 3. Executive drawing and realization of squared Table 4300 and its realization. Kartell 1983–in production (images from Morozzi, pp. 108–110 [28]).

common heritage only when it is expressed and communicated and when the message has been answered. I believe that this need for pragmatism, for commitment in completing one's work is a female characteristic" [29].

During the Second World War, in 1943, Anna Castelli Ferrieri, a young architect from a bourgeois, wealthy and culturally progressive family, graduated from the Milan Polytechnic. She was the only woman in that year's course. At those times, it was a rare exception due to a privileged family context.

Anna Castelli Ferrieri immediately began to collaborate with important architects such as Franco Albini and Ignazio Gardella, thus perfecting her inclination to impeccability in her works. Then, she reached a prolific collaboration with Kartell in the 1960s, until 1987 when she won the Compasso d'Oro award for the seat model 4870 (Fig. 2). Over these years, alongside her husband Giulio Castelli, chemist and founder of Kartell, she discovered the realm of artificial polymers and their potential in design. Her involvement with plastics was not instrumental but deeply cultural and semantic: her expressive codes were linked to plastics and their evolution; her design hope found its most complete expression in plastics, because plastics "spur to impact with innovation processes", because they force us to think in terms of complexity [28].

"We have been slow to realise that the balance of natural matter lies in the continuous cycle of its existence: it is born, grows, dies, and returns to the cycle in another generation. Succeeding with the artificial is our current creative task, not easy but not impossible and it is everyone's job to participate in this great undertaking" [30].

This is an optimistic and maybe anachronistic position towards polymers of petrochemical origin. In her vision, plastics are designed a priori: the material is assembled according to what you are going to design. She soon realised that plastic is a product to be designed, whose production efficiency can be improved, the appearance changed, and the performance adapted to the project needs. A clear example was the Table 4300 where the top is ribbed to ensure structural stability with a thickness of 7 mm while the ribs are 3 mm in order not to create suction and not to mark the outside of the top (Fig. 3). The project of the artifacts is closely related to that of the material and to the execution technique: the colours, the marbling, the patinas, are not finishes applied during the final stage of the product, but are born integrally with the product, being part of it from the earliest phases [28].

For Anna Castelli Ferrieri, the communicative power was fundamental for the success of a project, and the message was strongly related to the material. The project, which she always indicated as industrial design, must speak to people, and is quantified in sales: the design message is strong when it is widely received and welcomed. This stands in contrast with the factors determining the success of a good project nowadays, which also include the questions concerning the production – consumption – waste impact on the environment and our relationship with our artifacts and habitat [31]. Furthermore, Anna Castelli Ferrieri's approach diverged from the material approach of nowadays in terms of the "implemented" type design: according to Castelli Ferrieri the design must be perfect down to the smallest detail because the result must correspond to the original design. In contrast, today the material culture in design and production is focused on natural materials which in some way actively suggest the design direction thanks to their material vivacity [8].

6 Makers and material design culture nowadays

The democratisation of digital technologies has opened new opportunities for anyone to engage in creative acts and to contribute to an increasingly diffused phenomenon of social creativity, characterised by the culture of participation, of which digital technologies are an integral part. Like a multiverse, it is a complex system, unitary and manifold at the same time, which cannot be understood in its intrinsic unity. It is constituted by different and parallel communities of prosumers, amateurs, bricoleurs, crafters, makers, and professionals that grow around different types of creatives [32].

Following the Actor-Network-Theory [5], where technology, artifacts production, and society are reciprocally constitutive of a network linking human beings and non-human entities, more than ever nowadays the debate on material design and its application is necessary, due to our climate and habitat conditions. A case to consider is the emerging women's Do-it-Yourself, which includes makers and material design culture. Much has already been written about how material design is becoming an increasingly attractive field of research and experimentation for women designers and researchers as it represents the first step to the project narrative and sustainable perspectives [8,33,34]. A positive example comes from Shahar Livne, material and conceptual designer based in Eindhoven. Her research starts from the creation of new materials, through which a strong message is spread. For example, the project *Lithosplast* is an experimental composite material made of residues from industrial waste streams composed of a mixture of different plastics and dirt that cannot be recycled (Fig. 4).

Similarly, for Anna Castelli Ferrieri, artificial polymers were the beginning of the project's story. Nowadays, with the contemporary consciousness towards environmental issues, material innovations and choices are becoming more and more central in the valorisation of a project and its semantic and interactive value [35]. Materials are a strong vehicle of communication, emotions, and experiences through the substantial sensory features that they manifest, and this is a highly considerable aspect for women designers and researchers [19]. Over the past decade, the Materials Experience approach [36], and the Design-driven Material Innovation Approach [37] are expanding their diffusion and relevance in design thanks to the work of many women.

Today, as an effect of the design expansions, the ways of practicing design generate a *multiverse*, for instance a set of coexisting and parallel universes. From industrial design to *design art*, the expanded creative class acts with a combination of practices involving a mix of creative capability, technical ability, aesthetic judgement, community spirit, innovation, and material experimentation [38]. This process involves craft, art, design, technology, electronics, AI, public realm, and science, as well as common users, who are turned into active designers. Carried out by freelancers, contract micro-entrepreneurship or DIY, design activities can vary over time and result



Fig. 4. Lithosplast by material designer Shahar Livne. Mine-stone spoil, a solid residual material from the mining of coal containing sandstone, shale, mudstone, and coal fragments with dust residues (courtesy Shahar Livne).

in flexible labour. This expanded creative class, like those presented by Richard Florida, generates ideas, and regards the aesthetics of making artifacts as a cultural economy [39]. As a result, it is possible to witness the rise of a new economic phenomenon, in which a large number of independent designers work actively in the process of cultural development [19].

In this broad framework, the social processes originated by design practice are influenced both by the individual designers and by the design group and by group processes as well as by external factors such as external agendas, goals, time limits, available people, resources, and power games beyond the control of the group, where designers and makers have genders. However, design research and history still lack literature on the importance of gender dynamics and mostly the gender-material relation does not appear to have been dealt with yet in a systematic way [8,19,34–36,40].

At an international level, these informal creative practices constitute a complex and contradictory arena reflecting the entanglement and discrepancies of feminine emancipation, empowering processes and, in general, of our society itself. In each country, the phenomenon exhibits a different size, peculiar features, and *raison d'être*, but also common elements [41]. The origins of the phenomenon are connected to a reaction to the global financial crisis of the last decades and the subsequent austerity in the USA and Europe. They are also linked to the gendered labour inequalities, as well as the lack of recognition of women's contribution in creative work. Italy is an excellent example of this phenomenon, particularly in the arts, more than in the crafts field. The phenomenon challenges traditional visions of women's production in the domestic place for money or hobby as purely amateur production, or in organised FabLabs, democratically accessible to everyone. In some cases, it is reminiscent of the ideology that originated the Arts and Crafts Movement, since many of its expressions refer to an ethical attitude towards life, work, and environment, as well as a critique of industrial society and capitalism. But this revamping also includes



Fig. 5. A photo of the Design4Materials researchers network during a meeting at the Politecnico di Torino (courtesy Design4Materials).

non-political motivations, such as a consumers' demand for unique items as a reaction to the perceived impersonality of globalised industrial production. The handmade, unique, customised piece acquires desirability at market level and stimulates a return to lost female craft practices. In this sense, the phenomenon is reminiscent of the early-mid-1950s USA scene, characterised by the burgeoning consumerism in product sectors such as home craft and interior decoration. There are also similarities with the 1960–1970s feminism arts and crafts expressions of counterculture to respect in a society dominated by the white cisgender male [19].

7 Statistics on gender differences and equality

A study on makers movement (defined as the overlap between the fields of Digital Fabrication, Community Awareness Platform, Creative Industries and Craft & Do-it-Yourself), related to the EU MAKE-IT project, shows the differences between results achieved by females as compared with male leaders in maker initiatives [42]. Although both males and females use the same technologies to a similar extent, women tend to have a more sustainable impact than their male counterparts [42]. This study also shows a difference in hard skills acquisition: males are slightly more likely to be involved in modelling, software development, robotics, and Internet of Things (IoT), while females tend to use a wider range of technologies and to be less specialised in their technology use. Major differences between male and female emerge also in soft skills: learning is more important for males, whilst socialisation and inclusion through interaction and communication are crucial skills for females. Unfortunately, despite women-in-tech being a rapidly

growing phenomenon, it is still a minority. In fact, women's participation in FabLab 190 Women and maker cultures is low if compared to men. In the 3D printing field, women only represent 12% of the people involved, as reported by Sculpteo and Women in 3D printing in 2019 [42]. The issue of women's underrepresentation in the material design culture represents a contemporary challenge to achieve gender equality in the 21st century [43].

A solid example in Italy is represented by Design4Materials (Fig. 5), with 90% of feminine presence: a research network founded by the laboratories of leading schools of design such as Madec|Politecnico Milan, MaterialdesignLab|Sapienza Rome, HybridesignLab|SUN Naples, Soft Surfaces and Polisensoriality|Poliba Bari, all founded and coordinated by women, researchers of design.

The purpose of the network is to play a leading role in the design-driven innovation process, responding to society's changing needs and developing a "circular" methodology of innovation from a design perspective [44]. Another project to consider is MaDe – Material Designers – a well-mixed gender research platform co-funded by Creative Europe Programme of The European Union, demonstrating the positive impact Material Designers can have on the generation of alternative creative industries aiming at circular economies, and across all industries [45]. The scientific coordinators and most of the investigators of this project are women. The same holds for the participants in the organised workshops during the research to boost talent towards circular economies.

Therefore, if in the academic area the gender gap is less strong, the real question is what happens after graduation, when the doors open to the job market? It appears that the situation becomes complicated and in some ways reverses. The Gender balance publication 2021–2023 of the Politecnico di Milano [46] shows employment data of

TABLE 1: EMPLOYMENT RATE, PERMANENT POSITIONS AND AVERAGE NET SALARY BY GENDER, FOR BACHELOR DEGREE GRADUATES, AT 5 YEARS AFTER GRADUATION.						
BACHELOR GRADUATES 2015 (5 YEARS AFTER GRADUATION)						
	ARCHITECTURE		DESIGN		ENGINEERING	
	Women	Men	Women	Men	Women	Men
Occupational rate	94%	96%	94%	96%	100%	99%
% of permanent positions	75%	83%	79%	81%	92%	93%
Average net monthly salary	1.470 €	1.849 €	1.544 €	1.602 €	1.919 €	2.070 €
Sample size	98	141	159	97	74	368

TABLE 2: EMPLOYMENT RATE, PERMANENT POSITIONS AND AVERAGE NET SALARY BY GENDER, FOR MASTER DEGREE GRADUATES, AT 5 YEARS AFTER GRADUATION.						
ITALIAN M.SC. GRADUATES 2015 (5 YEARS AFTER GRADUATION)						
	ARCHITECTURE		DESIGN		ENGINEERING	
	Women	Men	Women	Men	Women	Men
Occupational rate	96%	98%	96%	99%	99%	99%
% of permanent positions	73%	81%	87%	92%	92%	92%
Average net monthly salary	1.652 €	1.883 €	1.754 €	2.020 €	2.037 €	2.237 €
Sample size	277	220	135	77	385	1159

TABLE 3: EMPLOYMENT RATE, PERMANENT POSITIONS AND AVERAGE NET SALARY BY GENDER, FOR PHD GRADUATES, AT 4/5 YEARS AFTER GRADUATION.						
Ph.D. GRADUATES 2015-2016 (4/5 YEARS AFTER GRADUATION)						
	ARCHITECTURE		DESIGN		ENGINEERING	
	Women	Men	Women	Men	Women	Men
Occupational rate	89%	94%	100%	100%	93%	96%
% of permanent positions	52%	67%	55%	50%	67%	70%
Average net monthly salary	1.673 €	2.052 €	1.950 €	1.850 €	2.124 €	2.374 €
Sample size	45	35	12	5	85	199

Fig. 6. Data tables from the Gender Equality Plan 2021–2023 report by the Politecnico di Milano (courtesy Politecnico di Milano).

Italian graduates between bachelor's degree, master's and PhD courses in architecture, design, and engineering (Fig. 6). These data present several gaps in employment and remuneration where males have an advantage in both aspects, especially in the fields of architecture and design. If rates are more aligned by gender, permanent positions tend to go more to men than to women. There is still a long way to go for rights and equal wages [44,47].

8 Conclusion

In virtue of the welcomed ANT – Actor-Network-Theory [5,48], gender issues are finally embedded in the technology and material design discourses. Therefore, women's representation in design is not only an equal employment opportunity issue, but crucially it is also a mirror of how the world is shaped and for whom. We live in a technological culture, a society that is constituted by science and technology, and so the politics of technology is integral to the renegotiation of gender power relations [49]. Science, technology, artifacts, and material design are treated as

simultaneously semiotic and material, where also marketing and consumption are part of the social and gender development. This “material-semiotic practice”, which makes it easier for us to understand our relationship to artifacts and technology, is essential for the relationship between the binary gender dichotomy and eventually the entire gender spectrum. The premise for all research on gender characteristics is that research takes gender traits to extremes, but gender is a continuum of possibilities and everyone's position on this scale can vary. At the extremes there are the extreme male and the extreme woman, at the centre the unisex. This extremization serves to make a complex world easier to understand. The way in which gender shows itself in a specific situation is a combination of the genetic-biological disposition of the individual, culture and conditions relating to a given situation. In this framework, the contribution of Donna Haraway with her Cyborg Manifesto, has been a pillar for the feminist relationship with technology development and artifacts [50]. Almost 40 years later modern human bodies, whatever the gender, interactions are made and regenerated through science technology, objects, and materials: they too are

technological artifacts [51]. Moreover, concerning feminine action in the design discourse, we are protagonists of a rising scene of female designers and makers, alongside the broad research female network including teachers and researchers in the field of material design.

To overcome stereotypes, we should work on the diversity of each person, highlighting female and gender diversity traits and preferences that are generally mostly overlooked by white cisgender male developers. However, this is not enough. If we are to address the gender gap and solve the challenges facing society, women must be championed as the active protagonists of technology, artifacts, and material development that they always have been.

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