Shifting spaces in fashion: approaching digital design spaces from a physical perspective

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Digital design processes reduce the degree to which designers physically engage with materials when designing garments. While extended-reality technology such as augmented reality and virtual reality can address the lack of physical involvement in digital design processes, it has yet to be fully embraced by fashion-design practitioners in academia and industry. The research presented in this paper aimed to explore extended-reality technology as an enabler of ‘design interspaces’, which mediate physical experiences and interactions with digital material based on spatial and technological affordances. The design interspaces that emerged as hybrid design spaces allowed varying degrees of physical engagement with digital materials. Workshop-based design activities involving extended-reality technology suggested that hybrid design spaces allow craft-based design activities that are commonly reliant on intricate human-body movements, such as knitting and draping, to be translated into the digital. They also suggested that physical engagement with digital content in an immersive manner can lead to consideration of wearability and interaction-based body-dress relationships during design processes. The findings contribute to the discourse on digital design practices within fashion, as they open up for thoughts regarding what may be lost when engaging in digital-only design processes that are streamlined for specific ways of working. The suggested usage of extended-reality technology reintroduces the concept of ‘messiness’ through physical engagement, which can contribute to engagement with digital technology in fashion design beyond considerations such as efficiency and productivity, leading to a move towards more diverse and versatile digital and hybrid design experiences.

Keywords: digital fashion; design spaces; digital material; body as material

1 Introduction
The increasing digitalisation of design processes in fashion within academia and industry is changing how designers experience and interact with the body and dress. While designers were historically trained in analogue skills such as draping, pattern construction, and craft-based material manipulation, an increasing number of academic institutions and companies are leaning towards digital alternatives and adapting to more ecologically and financially sustainable practices (Bertola & Teunissen, 2018;
Taking the digitisation of design processes in fashion into consideration, it is reasonable to ask how analogue skills such as draping and craft-based material manipulation are translated into 3D CAD software from a bodily perspective (Särämäki, 2021). What used to be a complex interplay between the body and fabric that required the designer to move in a three-dimensional space around the body to drape (Malmgren de Oliveira, 2018; Thornquist, 2015) has shifted to digital design spaces that provide a lesser degree of physical involvement in the design of garments (Atkinson, 2017). While it is true that developments in extended reality (XR) technology such as virtual reality (VR) and augmented reality (AR) allow digital content to be engaged with from a fully-bodily perspective within immersive spaces – and as such could reintroduce a degree of physical involvement in the design of garments – they have found little use within fashion design outside of promoting already-finished collections digitally through virtual catwalk shows (Jung et al., 2019) and digital try-on mirrors (Iannilli & Spagnoli, 2021; Kim & Cheeyong, 2015), for example. Seen from this perspective, the absence of XR technology in fashion-design processes is surprising given both the focus of the discipline on the human body, bodily perception, and interaction with design materials, and the fact that other design disciplines, such as architecture and interaction design, have shown a wider acceptance of this technology over the past 20 years (Kuntz et al., 2017). Both academia and the fashion industry could benefit from investigations into digital spaces – and digitally mediated spaces – as constituted by XR technology in terms of their mediating affordances of the body and materials within design processes. This could support alternative design approaches that are more cognisant of fashion’s body-centric heritage (Logaldo, 2016).

The research presented in this paper contributes to this discourse by exploring digital technology, and XR technology in particular, in design processes beyond its role as a tool, and towards the idea of it being a mediator and transformer of design spaces. Digital technology was not seen as simply an interface – two-dimensional screens and input devices to navigate the digital in three dimensions – but as an enabler of interspace. Interspace considers digital technology’s role as an interface, yet simultaneously acknowledges the three-dimensional space that is crucial to body-centric design disciplines such as fashion design. As such, interspace is here not only “a space between two or more bodies and things” (Oxford English Dictionary, 2023), but a space in which these bodies and things can co-exist and interact, whether they are physical or digital.
With respect to design processes in fashion, *design interspaces*, which suggest a body-inclusive alternative to established design approaches with digital technology, are explored and presented. They allow digital and physical content to be engaged with to equal extents from a bodily perspective during the design process, analogue skills such as draping to be engaged with in the digital, and the potential of digital-based craft to be explored.

2 Related studies

Shifting between physical and digital spaces using XR technology has been investigated from various perspectives in the context of fashion design.

Researchers have explored VR sketching applications as substitutes for physical sketching (Lee et al., 2021), developed applications to automatically translate immersive digital sketching processes experienced in VR into pattern constructions, similar to design processes in CLO3D and Browzwear (Joundi et al., 2018), and created VR sketching applications within educational settings to improve the communication of design ideas between lecturers and students (Starkey et al., 2021; Kyoung Yang & Hyun Lee, 2021).

Connecting physical and digital bodies has been investigated by using motion-capturing systems to connect human bodies to digital avatars in order to animate digital textile movements, and vice versa (Smitheram, 2015; Tepe & Saleem, 2021). Similarly, three-dimensionally scanned dressed human bodies have been used as digital reference bodies for designing dress (Atkinson, 2015; Thiel, 2015; Tepe, 2022), and the textures of garments worn on the body have been replaced with digital patterns (Mackey et al., 2017).

Researchers have reflected on the implications of digital environments for showcasing fashion collections using VR technology (Hong & Ge, 2022, Duck-Ki et al., 2023), and explored the current limitations of fashion-based products in virtual environments through digital fashion weeks (Iszoro & Amond, 2023).

The use of AR technology has been investigated with respect to QR codes as digital garment extensions (Häkkila et al., 2017), on human skin to create alternative expressions of dressing (Logaldo, 2016), and within prototyping processes for electronic garments (Ta et al., 2018).

3 Theoretical framework

Postphenomenological concepts were used to guide the research presented in this paper. The chosen conceptual framework was intended to break with established modes of thinking about digital technology in fashion-design processes, moving it away from being a tool and towards exploration of its mediating affordances with regard to the experience and constitution of design processes, spaces, and materials.

According to Peter-Paul Verbeek (2005), postphenomenology deals with the subject and object as entities that are constituted in their mutual relation, rather than as pre-given entities that assume relations with each other. Digital technology influences the user as much as the user influences digital technology (Latour, 1994), and therefore transforms the user’s perception by amplifying the perception of some things while reducing that of others (Ihde, 1998; Verbeek, 2005; Rheinberger,
In this context, the research presented in this paper followed Ihde’s (1990) notion of relational perception – the relation to the world made possible through technological artefacts.

Since the research presented in this paper dealt with a variety of devices and software, it was necessary to engage with digital technology on ontic and ontological levels, in order to consider the shifting perception of design spaces that emerged when moving from one technology to another. In other words, despite the affordances specific to the various devices and software packages, it was through their interconnectedness that they revealed alternative potentials for using them. Devices and software packages transcended their roles as tools for specific purposes and mediated both each other, in terms of how they were used and interacted with, and the content that was produced using them (Verbeek, 2005). Consequently, the research presented in this paper attended to what Ihde (1993) terms ‘multistability’, wherein technology holds different meanings in different contexts. The research activities were not intended to result in a design process in which technology is used in a predefined configuration or alignment of devices and software; rather, the intention was to shed light on technologies and their impact on the bodily experience of design spaces.

4 Exploratory experiment

Informed by the theoretical considerations as outlined above, ways of connecting different kinds of digital technology were explored within combined design processes for creating digital garment expressions.

4.1 Initial explorations

Possible ways of combining different kinds of digital technology, including XR technology, within design processes were explored. More precisely, XR technology, such as VR devices and AR editors and filters, was used to the same extent as 3D CAD software such as CLO3D in the design of digital dress. Possible configurations of digital technology were tried within design processes to investigate how they constituted physical and spatial experiences of engaging with digital design material. As shown in Figure 1, design processes with digital technology were structured into three stages during that process: Design ideation, Design development, and Design(ing) experience. This allowed better identification of what stages of the design process different kinds of digital technology constituted shifting degrees of physical interaction with digital content.

Reflection on the initial explorations suggested two factors that influenced how the design experience was constituted by the affordances of the physical-digital design spaces. The first was the use of AR and VR technology during the Design ideation and Design(ing) experience phases: their inclusion allowed physical engagement with digital bodies and objects that resulted in body-related interactions that are impossible in the physical (e.g. walking in and through digital bodies and materials, or merging these into one object). The second factor was the transitions that the designs underwent when they were transferred from the physical to the digital, and vice versa. Importing and exporting the designs from one software package into another partially merged design components that were initially separated. This disrupted the prevalent understanding and handling of the body and dress, and thus suggested the need to find alternative approaches for engaging with them in the design process.
4.2 Outlining design interspaces

The above-mentioned considerations led to the development of the model shown in Figure 2, which was intended to provide a better understanding of the role of digital technology in constituting design interspaces at various points in the design process.

In the model, technologies are placed on a physical-digital spectrum with regard to their mediating affordances in relation to the physical experience of the design space and process. Digital technologies that were engaged with by the human body in physical space are located to the left, while technologies that led to design experiences that were less connected to physical space and the physical body are located to the right. Within this spectrum, four design interspaces, which related to the design experiences regarding body-space interactions constituted by digital technology, were defined:

- **Design interspace A** related to physical interactions with technological hardware which function as input/output interfaces for accessing digital content, such as computers and head-mounted displays. Here the focus was on navigating the hardware in the physical from a bodily perspective, without engaging with digital content.

- **Design interspace B** outlined where experiences of physical and digital spaces overlapped to a somewhat equal extent; interaction between the human body and digital content was facilitated by mounting technological devices on the physical human body and changing the positions of devices based on the movement of the human body.

- **Design interspace C** involved experiences with digital content in digital space in such a way as to allow the properties of the human body and fabric to be simulated in terms of movement, collision, and deformation. Physical interaction with digital content was more in the background and point-and-click commands based on digital functions and tools were in focus.
• *Design interspace D* grouped together experiences of digital content wherein the behaviour of digital objects and bodies was not simulated according to their physical equivalents. Physical interaction with digital content was reduced to performing actions in the digital based on digital functions and tools, similar to Design interspace C.

![Diagram of design interspaces]

Figure 2. Classification of design interspaces along a physical-digital design spectrum, and placement of digital technologies on this.

5 Workshop

Based on the initial explorations and the development of the model, a workshop was planned in order to investigate i) the mediating affordances of digital technology with regard to the physical experiencing of design interspace, and ii) how the digital augmentation of design interspaces influence the design process and outcome.

5.1 Participants

The workshop was held over the course of five consecutive days with 15 first-year undergraduate fashion-design students. The majority of the students were Swedish; 12 were female and 3 male. All of the participants had prior training in traditional fashion-design practices such as pattern-cutting, draping, sketching, and sewing. Additionally, all had undergone a five-week course on various kinds of digital design software earlier in their studies. This included three-dimensional CAD software such as CLO3D and Blender, as well as VR devices and applications such as Oculus Quest, Google Tilt Brush, and Gravity Sketch. The participants had no prior knowledge of Adobe Aero, Adobe Dimensions, Meta
Spark, and Snap AR, and so they learned about these software packages independently during the workshop.

5.2 Setup
The workshop was held on campus between 9 am and 5 pm each day. The participants had access to Meta Quest VR devices with Gravity Sketch and Google Tilt Brush pre-installed and licenses for CLO3D, Adobe Aero, Adobe Dimensions, and Adobe Illustrator. Additional software, such as Blender, Meta Spark, and Snap AR, was downloaded and used by the participants free of charge.

At the beginning of the workshop the participants were randomly divided into five groups, each consisting of three members. The participants were then presented with the objective and assignment of the workshop: to use AR and VR technology and 3D CAD software in any configuration to create fashion-related experiences. The intended outcome was intentionally vaguely formulated in order to avoid limiting the participants in their explorations during the various phases of the design process. The participants could design whatever they wanted, as long as the design outcome included AR projections – the objective was thus not to create physical or wearable garments, but experiences that were, in one way or another, fashion-related. The participants were told to work only with their groups for the five days, but were able to meet with the author to discuss problems or challenges regarding the different kinds of technology.

5.3 Data analysis
The design processes of each of the five groups were reconstructed using imagery, videos, and three-dimensional designs provided by the participants at different stages of their design processes.

A matrix was developed based on the models shown in Figures 1 and 2 to analyse the design processes and at which stages the designs and physical interactions existed and took place in the physical and the digital. The technologies used were arranged along the x-axis with respect to the design stages of Design ideation, Design development, and Design(ing) experience (Figs. 3–7). Their placement along the y-axis relates to which design interspaces were engaged with in the design process. This facilitated comparison of the design processes of each group, and identification of commonalities and differences in terms of their usage of digital technologies at different stages of their design processes. This supported identification of the mediating affordances of digital technology, in terms of how it constituted the participants’ design interspaces and affected physical interactions with design materials at specific stages of the design process.

5.4 Design outcomes
In this sub-section, the design processes and outcomes of each group are presented and the way in which the digitally constituted design interspaces may have influenced the participants’ design activities and when in the design process they emerged discussed.

Group 1 generated ideas for their design primarily in CLO3D. Working only with one software package – and one that is specifically tailored to fashion designers’ needs during the ideation phase – at this stage influenced the participants in creating a recognisable garment expression, as well as how they approached other software packages and devices in the later stages. They used materials in relation to the digital human body in a way reminiscent of how this is done in CLO3D (Image 1 of Fig. 3), despite the design interspace’s level of physical interaction and immersion in VR (Image 2 of Fig. 3). Shifting the design process back to more conventional digital design processes with 3D CAD software further
streamlined the digital design outcome (Image 3 of Fig. 3), and led to the group showcasing their design using AR filters, projecting it as a static object in the physical without bodily interaction (Image 4 of Fig. 3).

Group 2 worked in Design interspaces A and B during their design ideation; one participant designed garment patterns in CLO3D, and another created textile structures in Gravity Sketch. The latter created digital material in VR that resembled knitted structures by sketching intertwined three-dimensional loops based on full-body movement (Image 1 of Fig. 4). Shifting between design interspaces early in the design process motivated the participants to explore the function-specific affordances of technologies which made soft and movable materials rigid, and vice versa (Image 2 of Fig. 4). Based on these explorations, the participants worked in immersive three-dimensional spaces in VR to create material expressions using craft techniques more commonly associated with physical design practices (Image 3 of Fig. 4). Despite engaging with digital material in Design interspace B, the group decided to project their digital design into the physical without further bodily interaction (Image 4 of Fig. 4).
Group 3 primarily worked in Design interspace B during their design ideation by working in VR. They draped already-available digital objects on a digital human body, observing their designs by walking around them. This allowed them to explore accidental development, such as objects interacting with each other in ways that would not be possible in the physical, for example surfaces becoming combined rather than colliding (Image 1 of Fig. 5). Inspired by this, they moved between Design interspaces B and C to explore glitch-related expressions, based on the idea of colliding and intersecting objects and materials (Images 2 and 3 of Fig. 5). Their initial explorations influenced their decision to create an AR experience that changed expression when seen from different perspectives: when viewed from some angles in the physical, ‘Error’ windows would appear next to the design, representing their experience of glitching objects only displaying correctly from certain perspectives in VR (Image 4 of Fig. 5).

Group 4 primarily worked in Design interspace B during their design ideation, working in VR. Unlike Group 3, this group modified the body itself, altering its shape by three-dimensionally sketching forms on its limbs (Image 1 of Fig. 6). This led to alternative human body forms that caused a shift in their perception of the body: from a thing to design for, to a design material. Having morphologically altered the body in VR, this was draped on in CLO3D (Image 2 of Fig. 6) to then work with the designed garments as substitutes for the body by removing the avatar body (Image 3 of Fig. 6). Their experiences in Design interspace B allowed them to experience and perform modifications on the digital human, and motivated them to create a design experience using AR devices that involved bodily interaction through projecting their design onto a physical body (Image 4 of Fig. 6).
Figure 5. Overview of Group 3’s design process and use of digital technology.

Figure 6. Overview of Group 4’s design process and use of digital technology.
Group 5 primarily engaged with Design interspace B during their design ideation, working in VR. Influenced by the idea of physically experiencing and interacting with digital content, they three-dimensionally sketched abstract objects by tracing body movement using a VR controller. The objects were conceived as body alternatives, and were further explored in Design interspaces C and D by draping textiles in CLO3D (Image 1 of Fig. 7) and changing their material properties and textures in Adobe Dimensions and Blender (Image 2 of Fig. 7). The body-fabric interactions produced at the beginning of the design process guided the group in designing body-fabric expressions using AR technology. Meta Spark was chosen as the AR content editor for this purpose as it allowed the group to see their bodies projected in the digital space, making it possible for them to visually experience digital content from a body-related perspective during that stage of the design process (Image 3 of Fig. 7). In parallel, the group designed a QR code that was printed on a physical T-shirt, which activated projection of digital content on the wearer’s body when scanned and looked at with a smartphone camera (Image 4 of Fig. 7).

Figure 7. Overview of Group 5’s design process and use of digital technology.

6 Findings

The combining of 3D CAD and XR technology continuously moved the design process between the digital and the physical, which changed how the workshop participants experienced and interacted with the digital content. Transitioning back and forth between one digital space – which was interacted with on a 2D screen – and another, more ‘immersive’ one – which was interacted with in three dimensions through full-body movement – required the participants to continuously re-explore their designs through bodily involvement. This facilitated exploring body-dress expressions that
deviated from how they are commonly designed, expressed, and interacted with in digital design processes. Three main observations were made in this respect, relating to Interfaces and interspaces; Body awareness and body affectedness; and Material translation and software transition.

6.1 Interfaces and interspaces
Comparing the design processes of each group suggested that the earlier in the process technology was engaged with, the greater the influence it had on the overall design direction. This related not only to visual design decisions regarding the textures, silhouettes, and proportions of garments of the digital body, but to how the final design outcomes were intended to be interacted with from a bodily perspective. Groups 3–5 primarily engaged with digital technology during the ideation phase and within Design interspace B, which allowed them to physically engage with digital content by moving and rotating their bodies with or around it, setting design materials and objects in relation to their bodies, and walking inside and through digital content. As a consequence, the design outcomes of Groups 3–5 were designed to be responsive to the human body when projected in the physical using AR technology. In contrast, Group 1 primarily worked with digital technology in Design interspace C at the outset of their design process, which did not involve physical interaction with digital content. While their design outcome was clearly visually related to the idea of a wearable garment, their use of AR technology to project their designs into the physical appeared to be relatively static and non-interactive. The reduced physical involvement and interaction with digital content was given consideration in the early stages of the digital design process, meaning that factors such as wearability and physical interaction with digital designs were less important in the later stages. In connection to the postphenomenological considerations discussed in Section 3, the different design interspaces amplified the perception of one thing – wearability and interaction in the case of Design interspace B – and reduced that of another – accessibility in the sense of commercial aesthetics. As such, the design experience and process were not mediated and constituted by digital technology alone. While the space in which the participants designed was defined by the affordances of the various kinds of technology used, it was the interplay with the physical space in which the participants moved that shaped the design interspaces with varying levels of bodily involvement.

6.2 Body awareness and body affectedness
The combined spatial and technological affordances that were experienced within Design interspace B changed the participants’ perspectives on the role of the human body in design processes. The participants engaged not only with digital content from a bodily perspective – by walking within or around digital materials, scaling them in relation to their body size, and deforming them based on their body movement – but with digital human-body representations as design materials, rather than as things to design for. Digital human bodies were morphed and altered in terms of their shape and size (Images 2–3 of Fig. 5; Images 1–2 of Fig. 6) and texture and materiality (Images 3–4 of Figs. 3 and 5) and repurposed to create interactive experiences involving physical engagement (Images 3–4 of Figs. 6–7). Equally, dress and textile-related materials were no longer engaged with for the sole purpose of applying them to the body, and were instead used to shape the body (Images 1–2 of Fig. 5; Image 2 of Fig. 6; Image 1 of Fig. 7), substitute the body into the design process (Image 3 of Fig. 6; Image 2 of Fig. 7), and be experienced as bodies themselves (Images 3–4 of Fig. 6).

There was a correlation between physical experience and engaging with digital bodies that shifted the participants’ perception of the role of the body towards considering it to be a design material when experienced in Design interspace B. This was particularly evident when Design interspace B was
engaged with early on in the design process. While Group 1 primarily worked in Design interspace C during their design ideation, Groups 2–5 engaged in Design interspace B to a greater extent and earlier in their design processes. Consequently, Group 1 used human-body representations in similar ways to how they are commonly employed in fashion-design processes in terms of function and purpose, while Groups 2–5 explored the functions and purpose of the body beyond established design approaches. Relating these observations to postphenomenological considerations resonates with what Verbeek (2005) describes as dealing with subject and object as entities that are constituted in their mutual relation, rather than pre-given entities that assume relationships with each other. Design interspaces mediated by digital technology shifted the participants’ perception of the human body and fabric at the intersection of the physical and digital – away from distinct entities and towards interchangeable design materials that informed each other in their becoming.

6.3 Material translation and software transition
The use of technological devices and software packages with varying spatial configurations led to alternative approaches to physical engagement with digital content, influencing how design materials were conceived of, explored, and interacted with throughout the design process. All of the groups experienced changes in material properties and behaviour when moving design materials and objects between design interspaces. Materials and objects that were rigid and non-interactive in one design interspace became soft and interactive in another (Images 1–3 of Fig. 4; Images 2–3 of Fig. 5; Images 2–4 of Figure 6; Images 1–2 of Fig. 7), were formed and deformed using point-and-click commands in one design interspace and full-body movement in another (Images 1–4 of Figures 3–7), and had set textures and material properties in one design interspace that could be changed freely in another (Images 1–3 of Fig. 3; Images 1–4 of Fig. 4; Images 2–4 of Figure 5; Images 2–3 of Figs. 6–7).

Making objects and materials that are generally soft into rigid ones, and vice versa, allowed the participants to explore alternative ways of engaging with digital content within their design processes. Group 2 explored craft-based material expressions using VR sketching to create deformable knit-like structures, which were then used as rigid bodies in the following steps. Groups 4 and 5 shaped fabrics in CLO3D by letting them collide with the body in the first step, then used the deformed fabrics as rigid objects in other design interspaces. Group 3 explored glitches or flaws that emerged as a result of moving digital content from one software package to another, causing materials that were separate in one design interspace to become impossible to separate in another, or disproportionate to one another when moved. Lastly, Group 5 explored the absence of collision algorithms and gravity in one design interspace, placing fabrics in proximity to the wearer’s body that would move in accordance with the movement of this body, rather than placing them directly on the body. The space between the body and the fabrics that were moving became a design expression that visualised body-fabric interactions that were made possible by proximity, suggesting alternative experiences of wearing dress. Analysing these observations in relation to postphenomenological concepts suggested that, despite the affordances specific to the devices and software, it was through their interconnectedness that they revealed alternative potentials for their use within design processes.

7 Discussion
Rather than following a binary dichotomy of the digital and physical as separate spaces, the findings presented in this paper suggest a physical-digital spectrum consisting of multiple and shifting
interspaces, each of which allows the design process and design materials to be experienced from varying perspectives. Digital technology was not engaged with solely based on device-based interfaces – predominantly two-dimensional screens through which one can navigate the digital with low physical interaction – but through interspaces – co-constituting agents in the form of XR devices and physical-digital spaces that mediate how bodies and materials are experienced and interacted with during the design process. The shifting degrees of physical presence in physical-digital spaces – in that the bodies of users were engaged in the process of making through movements that varied depending on the technology used – allowed the qualities of fashion-related products and experiences to be explored using digital technology in a way that fits with fashion’s craft-based history. This also allowed what fashion-related experiences can be to be expanded. The design process and outcome of Group 2 suggests the possibility of exploring digital craft-based expressions by creating knit-like structures through three-dimensional sketching with body movement, while those of Group 5 showed how fashion-related outcomes can introduce interactive elements to digital garments that could not be introduced to physical ones. Here, digital fabric shapes were placed in proximity to the wearer’s physical body and moved in accordance with it, raising awareness of the role of spatial proximity between body and dress in creating experiences of wearing.

While all of the participants saw the potential of using XR technology in fashion-design processes for the reasons outlined above, they also saw challenges in engaging in design processes with XR technology. The most commonly expressed of these was mental and physical fatigue: shifting back and forth between technologies that each had their own functions, ways of interpreting material properties and behaviours, and experiences and interactions required the participants to continuously change their mindset in order to proceed in the design process. This reduced not only the level of control but the degree of intuition, which fashion designers are often trained to rely on (Thiel, 2017). It is therefore necessary to increase the compatibility between technologies so as to make such transitions easier, as well as to train designers to better adjust to the specific challenges of designing digitally (Särmäkari, 2021; Varra, 2021). The other reason for mental fatigue was the shifting involvement of physical interaction in the design process. Shaping and modifying design materials with full-body movement was possible in one design interspace and not possible in another, resulting in less physical engagement and thus frustration among the participants. Hence, a more consistent physical experience of digital content with XR technology from design ideation to development and presentation would not only increase physical immersion throughout digital design processes (Lee et al., 2021) but help designers, who normally work exclusively physically by maintaining a degree of bodily involvement (Starkey, 2021), to better adjust to digital environments. Lastly, full-body engagement with digital content was described as feeling odd at times due to the lack of tactile feedback. Physical engagement with digital materials did not provide the same level of tactile response as physical design processes, which demand bodily awareness and precision when deforming materials through movement. As discussed by Yang et al. (2021) and Joudi et al. (2018), more research into immersive digital technology is required to simulate tactile stimuli for increased kinaesthetic precision, as well as to provide tactile sensations in order to communicate fabric-like qualities digitally (Ferrarello, 2017). This would reduce physical fatigue among fashion designers working digitally.

Seen in the wider context, the findings support those of Thornquist (2015) and Malmgren de Oliveira (2018) in that they acknowledge and emphasise the relevance of bodily engagement in design
processes in fashion. While the findings do not suggest a specific approach to design processes with digital technology, they reintroduce the relevance of physical engagement with design materials in digital fashion-design processes to create outcomes that are more strongly influenced by the factors of interaction, wearability, and body-dress relationships. As such, the findings may open up for questions about what we may lose when we engage only with digital design processes that are streamlined for disembodied ways of working, and as such eliminate creative friction along the way as proposed by Atkinson (2017), Thiel (2017), and Tepe & Koohnavard (2022). By bringing full-body perception and interaction into digital design processes – through design interspaces, enabled by XR technology – this research reintroduces the concept of ‘messiness’ through physical engagement. Digital technology can help us move beyond factors such as efficiency and productivity, and towards more diverse and versatile digital and hybrid-based design experiences.

8 Closing remarks
The research presented in this paper explored alternative perspectives on the role of digital technology in fashion-design processes, moving away from regarding it as an interface and towards seeing it as an interspace. Doing so allowed the role of the human body in fashion-design processes to be re-emphasised, and placed on a physical-digital spectrum. This alternative perspective departs from the dichotomic view on the physical and digital as separate entities, wherein the designer’s body is in the physical and design materials are in the digital. Future research could re-iterate the presented workshop with design students and practitioners in order to investigate the mediating affordances of shifting design interspaces and XR technology on designers more accustomed to established modes of practice and designing digital garments. Further, a longer workshop would allow the changes in design expression and experience to be explored in terms of factors such as novelty and inexperience. Lastly, more research is needed to map out the implications of these findings for academia and industry with regard to engaging with XR technology.

References


**About the Authors:**

**Jan Tepe:** Driven by concepts of agential realism and post-phenomenology, his doctoral research and design practice look at how digital technology can constitute body-dress relations in order to suggest alternative ways of exploring and designing fashion-related experiences.