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Digital 3D design as a tool for augmenting zero-waste fashion design practice
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ABSTRACT
This article describes the use of three-dimensional (3D) software in zero-waste fashion design, with a focus on its application in the context of the authors’ research and experience in industry and education. It expands on its use in visualisation for merchandising and marketing, to discuss how as a hybrid design and prototyping tool, 3D software could transform zero-waste design in industry, education and research. This research uses an experimental design approach and reflects on the authors’ design process before using 3D software, and its transformation upon learning, due to its utility for holistic 2D/3D practices. The article explores a range of examples of 3D software in use, revealing new design workflows that it allows for in articulating the relationship between form, pattern cutting and waste – and concludes that the advantages of 3D software to augment the garment design process is particularly evident for zero-waste fashion design.

1. Introduction
This article describes the use of 3D software (in this case CLO) in zero-waste fashion design, with a particular focus on its application in the context of the authors Artistic Research PhD. Zero-waste fashion design is the process of designing of garments which aims to prevent the creation of waste when the garment is cut and sewn (Rissanen & McQuillan, 2016; Townsend & Mills, 2013). Conventional fashion production wastes between 15 and 25% (Rissanen, 2013, p. 4; Runnel, Raihan, Castle, Oja, & Bhuiya, 2017, p. 19) of the cloth needed to make a garment. Most attempts in industry to reduce waste occur at the marker making stage, and not at the design stage where the majority of waste is determined. 3D software is often primarily used by the industry as a visualisation tool for merchandising and marketing; however, this article expands on this use to discuss how as an exploratory design and prototyping tool the software could transform zero-waste design practice in industry, education and research.

1.1. Research scope
After providing a context for the practice-based work, this paper reflects on the authors’ zero-waste design process before using 3D software, and – through a discussion of the authors’ contemporary design practice – its transformation upon implementing it. The case studies were undertaken between 2016 and 2019 in a range of contexts, and are grouped as following: education, industry and research. The article explores a range of examples of 3D software in use in these contexts, and reveals new workflows and resulting opportunities the use of 3D software allows for in the design process. In summary, it argues that the advantages of 3D software to augment the garment design process are particularly evident for zero-waste fashion design.

1.2. Fashion design process
According to Davis (in Lee & Jirousek, 2015), the goal of an apparel designer is to create aesthetically pleasing garments by manipulating design elements conditional on design principles. Hallnäs (2009) asserts that while the majority of the design industry seeks to solve a problem on some level, fashion differs in its primary goal to introduce aesthetic ‘difference’. Lee and Jirousek (2015), when articulating Cross’ (2001) ‘designerly ways of knowing’ for fashion designers, describe the ‘design process path that can be traced in every stroke of a professional designer’s sketches’ (Lee & Jirousek, 2015). This process of seeking aesthetic difference as achieved through sketching is the dominant design process taught to and utilised by fashion designers.
McKelvey and Munslow (2012) write that despite pattern cutting being an implicit part of the fashion design process, they will not discuss it in depth because ‘we are dealing with the basic design process’ (p. 16). Implying that pattern cutting sits slightly outside of basic fashion design practice. James, Roberts, and Kuznia’s (2016) articulation of the traditional fashion production process is divided into design and make. Here ‘Design’ includes – in sequence – research, ideation, concept development, design development and design selection. While ‘Make’ includes an iterative first patterns and second patterns stage, followed by production sample, factory sample and lastly final production. Here, like McKelvey and Munslow, design and pattern cutting are not part of the same stage of a process. Almond (2010), in contrast, writes that the ‘luxurious art’ of creative pattern cutting generally has a more holistic and collaborative approach between design and pattern cutting. Recent conferences dedicated to creative pattern cutting have highlighted the increasing rejection of the design–pattern cutting divide.

Of Fiona Dieffenbacher’s (2013, p. 12) two distinct fashion design processes – Linear and Random – creative pattern cutting likely fits into the later. The nature of the industry – that it is predominantly linear, siloed and cost-sensitive – means that divisible, sequential design processes are favoured. The more ‘random’ and holistic practices favoured by creative pattern cutters make an uneasy fit into most commercial fashion.

Rissanen (2007) expands on our understanding of design processes (including pattern cutting) by articulating eight design workflows from idea to sample (Figure 1), and discussed them for their potential to consider waste elimination. Written before the emergence of successful 3D design tools, Rissanen’s categorisation still provides a clear framework for the analysis of emerging workflows for zero-waste practice made possible with digital tools. Rissanen (2007) discussed the relationship between two-dimensional (2D) and 3D processes in fashion design and pattern cutting, and identifies that a number of commonly utilised methods can pose significant problems for waste elimination from the designers perspective. In 2013, he wrote:

In most fashion industry practice, a pattern is cut for a garment based on a sketch idea. When a fashion designer is sketching a garment, the shapes of pattern pieces and how they may interact on a fabric width are not considerations in conventional fashion design (p. 5).

It seems that in fashion design processes – particularly where the sketch or an existing garment is a critical design genesis stage (Figure 1: A, C, E and F) – there is a perceived loss of control over the design process if pattern cutting impacts on the outcome of the planned aesthetic. This may be due to a gap in knowledge about the pattern cutting process (designers do not always know how to pattern-cut the designs they sketch), or because they see the pattern cutting only as a tool or process which physically manifests a design that already exists. For these designers, if the process cannot manifest the design as originally intended, then the process is not working.

### 1.3. Zero-waste fashion design

Zero-waste fashion design could be seen as a practice concerned with solving a problem. When engaging with the zero-waste redesign of an existing garment – we know its overall desired form, but we strive to achieve something similar without making so much waste – so the design ‘problem’ is the waste. Even in a design where the aesthetic outcome is open, there always exists fabric width as the parameter or constraint, with the resulting ‘problem’ of waste to be solved. For the majority of brands utilising a conventional fashion process, the aesthetic, function and production costs are privileged over its impact on society and the environment. The assumption is that a holistic approach which addresses aesthetics, function, production and waste reduction is too difficult or is not desirable – or that it can be achieved as purely a function of pattern cutting and marker making, after the design is determined. Increasingly however – as consumer demand and legislative pressure mounts to address the climate crisis – these hierarchies may be challenged. Avoiding its production is a key step in the reduction of waste, so the fashion industry will need tools that enable designers to address issues such as waste within the context of the design process.

James et al. (2016) note that when zero-waste techniques were used ‘the sequence of a traditional fashion production process changed’ (p. 143). They describe the design process as an ‘almost trial-and-error approach’ where ‘when working in flat pattern format, the zero-waste principals worked; however once produced into a 3D garment, the fit, silhouette or shaping was wrong’ (p. 144). As a result designer and pattern cutter are required to repeat steps until the outcome in ‘theory’ and the outcome in ‘practice’ align. James et al. discuss five themes that emerge out of their research: communication issues, the role of the pattern cutter, input into the design process, collaboration and operational setup (p. 148–149). In their discussion, these themes all suggest a potentially problematic implementation of zero waste as a method in the reduction of waste in the fashion industry.

I have in the past described zero-waste design as a pattern cutting process, however, if the design – pattern
cutting demarcation is maintained, problems such as James et al. describe almost always occur. A holistic blurring of boundaries between design and pattern cutting is required for successful outcomes of zero-waste design—the visualising the 3D form, 2D pattern and fabric yield, to best meet the objectives of the design, need to occur all at the same time. This holistic approach was until recently difficult to act on and very hard to communicate to others. It is in this space that 3D software could emerge as a potential aid. By hybridising the actions and visualisation of the relationship between the 3D ‘sketch’, the 2D pattern and the 3D sample, digital design tools can enable a more holistic approach to garment design which may provide space for waste reduction practices to occur.

1.4. Digital tools

Unlike many other 3D design industries in which the use of 3D software such as ArchiCAD, Rhino and others have
transformed both workflows and outcomes – the fashion industry has been relatively slow at implementing the utilisation of 3D software in the design process. Almost all early 3D rendering programs were extensions of existing industry pattern cutting software. However, there was limited uptake in part because of the poor quality of the outcomes in terms of accurately rendering, and visualising attributes such as fit and drape. The relationship between the 2D plan or pattern and the 3D garment in fashion practice is arguably more challenging to visualise digitally than is the case for architecture (an early adopter of 3D software). The requirements for rendering the interactions of body, textile and gravity and the infinite variations possible for textile behaviour made the development of accurate software more problematic than for the predominantly hard materials used in architecture. As a result, the fashion industry has only recently begun to explore the use of such software broadly.

1.4.1. Examples of current 3D software use

3D design software is often primarily used by the industry as a visualisation tool for merchandising and marketing purposes. Ikea uses CLO to visualise textiles in interior settings, Balmain promoted their Autumn 2018 collection using the so-called first digital supermodel, Shudu, and two other digital avatars digitally dressed in their collection (‘Balmain’s New Virtual Army’, 2018).

A key attribute of the development of digital 3D software for fashion has been accuracy and application as a replacement for at least part of the prototyping process. Most 3D software now allows for the pattern to be visualised in 3D, and its pattern exported for use in production. The advantages are seen by many in the industry: 86 international companies are listed as current users of CLO, and Adidas, Patagonia, Amazon, Lindex, Li&Fung, Helmut Lang are all, at time of writing, recruiting for 3D digital designers and software users. Digital prototyping enables designs to be developed with minimal waste, and potentially to be ordered directly from a digital render. Swedish brand Atacac utilise 3D software in almost every stage of their business, from design/pattern cutting, to visualisation for online retail, through to exporting the patterns to be used in their micro-factory. In education, many fashion programs have introduced CLO courses into their curriculum (58 schools internationally at the time of writing). Increasingly, these digital tools are being integrated into more areas and segments of the fashion industry.

2. Research methodology

This research took an experimental (Koskinen, Binder, & Redström, 2008) and reflective (Schön, 1983) design approach. A phenomenological perspective is adopted, and by reflecting on the difference between prior practice and my experience now, I speculate as to the potential positive impact these tools may have. The four case studies are grouped into education, industry and research, though often these actually overlap – for example where research is undertaken in the context of industry.

2.1. Simultaneous and hybrid practices

This paper takes the position that zero-waste fashion design has always been a simultaneous, and increasingly a hybrid practice (Townsend, 2003). Beyond the colour, texture and behaviour of the textile that conventional fashion practice needs to consider, zero waste also has to address fabric width – a constraint that is usually outside of the designers’ control. This research discusses work at the intersection of textile and form design practices, similar to the way discussed by Katherine Townsend and colleagues (Briggs-Goode, Townsend, & Northall, 2010; Townsend, 2003; Townsend & Goulding, 2011). In simultaneous design, the designer operates in two fields at once, and the objects are both textile and form at the same time and their development occurs simultaneously. In hybrid design practices, the designer moves from one field to the other and back again, often utilising the tools of the respective fields in a hybrid way. The objects that emerge, as a result, are metamorphic, they transform, intellectually and sometimes literally, from one state to another. Marshall and Penge (2006) discuss the relationship between computer technology, transdisciplinary discourse and hybrid design practices, stating that ‘an increasing number of practitioners are able and willing to negotiate working across previously designated disciplinary domains’. To effectively operate in a hybrid manner, we need tools that enable translation between modes of work.

Hybrid practices are often also holistic practices. This lens is ever present as a result of the nature of zero-waste design – multiple perspectives and a broad understanding of the context the researcher is operating within is optimal. The degree of holistic thinking required varies across the different contexts, sometimes constrained by technology, other times by industry, or necessity.

3. Transforming zero-waste design practice through 3D design tools

While it is common to consider the use of digital tools for fashion in the context of visualisation of outcome or marketing, here, I am discussing visualisation in the design process. As an exploratory design and
prototyping tool 3D software could transform zero-waste design practice in industry, education and research. Next I will introduce the differences between a basic fashion design process, a basic zero-waste design process without 3D tools and how the use of 3D software transforms zero-waste design (Figure 2).

3.1. Design process before 3D digital tools

The zero-waste design workflow I used between 2004 and 2016 involved 2D digital tools such as Gerber pattern cutting software, Adobe Illustrator and Photoshop to develop the 2D zero-waste pattern and sometimes the textile print. In Illustrator, colour coding was used to aid in the understanding of the translation from 2D to 3D. Much of this design process occurred in the brain of the designer and articulating it clearly and visually was difficult and inaccurate. To pattern-cut the sketch – as is usual in many parts of the fashion industry – is difficult if not impossible with zero-waste fashion design. So to assist in visualising the desired outcome, throughout the design process, the 2D pattern was printed at small scale on paper, then cut and constructed using tape – forming a 2D/3D ‘sketch’ that enabled the development of designs to a more advanced stage before constructing at full scale in cloth (Figure 2, B). This process was relatively time consuming and commonly seen as a barrier to industry uptake, due to its complexity compared to the basic fashion design process (Figure 2, A). The toile stage was crucial as it was the first time an accurate 3D version of the design was made and often required multiple corrections to the pattern, and sometimes a wholesale rethink of the design.

The first four stages of the basic zero-waste design process prior to 3D software (Figure 2, C), replace the ‘ideation/sketch’ process of a conventional fashion design practice, while the remainder follows a more conventional fashion development practice, seeking to test the pattern. The major limitation in terms of a design process is that the digital 2D pattern–analogue 3D paper model process is not accurate since paper is not like cloth. Any sketch or design decision undertaken was partly an educated guess, informed by tacit knowledge (Polanyi, 2009) built from years of working with cloth and form under the limitations of zero waste. Being comfortable with risk is a requirement of all experimental design practitioners, but even more so when practising zero-waste design. However, too much risk can be paralysing.

3.2. The impact of 3D software on my practice

Tools which enable rapid ideation and clear communication of hybrid or simultaneous practices within fashion design were rare until the development of effective 3D
design software. It is their utility in a zero-waste fashion design context are discussed next.

The reality of the basic zero-waste fashion design process prior to 3D software, (as outlined in Figure 2, B), is that in practice the Digital 2D pattern – 3D paper model is repeated over and over again, similar to an iterative conventional sketching methodology. However, the outcome of these iterations is still mostly uncertain because of the inaccurate translations between digital, paper and cloth media in two different dimensions, within the goal of achieving a zero-waste marker. It is in this space that the potential transformational qualities of 3D software are apparent. This perspective is shared by zero-waste designer Mylène L’Orguilloux who utilises the software in her practice. She writes (https://www.milanavjc.com) that using 3D software allows her to design clothes digitally while simultaneously analysing the resulting marker. Consequentially, ‘meaningful modifications can be done virtually, without producing any fabric waste during prototyping and final cutting phases’. Upon learning 3D software, I could immediately see the potential for developing new workflows which hybridised many of the back and forward actions in my existing design practice – increasing the space for creativity, while reducing risk and material use.

### 3.2.1. Digital 2D/3D design

For many designer-pattern cutters, the relationship between 2D and 3D has always been fluid, but as its mutability exists inside the thought process of the individual, communicating to others, the 2D–3D relationship can be complicated. The experience of designing using 2D/3D software is that the relationship between 2D pattern design and 3D form design is fluid and permeable, and as it is visualised, this experience can be communicated to others. Digital 2D/3D design in the context of zero-waste fashion design hybridises the iterative transferal of 2D pattern shape to 3D garment outcome, and back again (Figure 2, C). 2D pattern design ‘moves’ or actions, from the grand to the minor are visualised immediately in the corresponding 3D avatar screen. The various actions involved in garment design and pattern cutting – which are usually either linear, siled or imagined by the designer – occur together and in direct response to the other. This hybridising of actions proves particularly useful for zero-waste design practice since it is inherently a holistic and hybrid practice already.

### 4. Reflections on practice

Next, this paper will discuss a range of examples the author experienced first-hand of the utility of 3D software for zero-waste design. Drawing from the authors’ research, these examples range from workshops with students, to large-scale garment industry projects, to speculative research experiments.

#### 4.1. Education

Many contemporary fashion design students explore simultaneous and hybrid practices in their work – moving beyond the application of print or embellishment to the form, they explore methods which integrate the design of form into the design of textiles. Tools that enable a fluid interaction between textile expression and 3D form are valuable in this space. Software such as CLO enables rapid and early design generation, which can then be translated directly to their outcomes.

In the context of education, in particular, it is important to stress that digital tools should be considered an addition – and not a replacement – to the analogue tools already in use. Building on tacit knowledge is essential in the digital context as it helps to anchor the students practice in real lived experience. For example, there is (so far) no way to replace the experience of wearing a coat and lifting your hand to place it into a pocket to feel that sense of ease when it has been placed in a comfortable location and angle. 3D software can be another tool fashion designers have at their disposal.

#### 4.1.1. Zero-waste workshops: conceptual idea – digital 2D/3D design – sample

Next, this article will discuss the use of 3D software in a zero-waste workshop for Make/Use (McQuillan et al., 2018) from both the perspective of teaching and student experimentation. In the workshop, a range of teaching tools is utilised for communicating the non-conventional zero-waste form construction possible using the Make/Use method.

3D software enables the rapid demonstration of construction and design ideas in workshop or classroom format. Rather than asking the students to imagine the changes possible – or make in full scale – the modifiable zero-waste patterns in Make/Use, digital samples of the Make/Use coat are altered live in the 3D digital space (Figure 3). Additionally, the software enables the easy sharing of videos showing how Make/Use garments are constructed. Feedback suggests this is highly effective at communicating the unconventional form-making process.

A key advantage of using 3D design software in education is in their use as learning tools. Once the initial hurdle of learning the software itself is overcome, it can be a relatively risk-free way of a student learning something new or trying an experimental form. In Make/Use workshops, students were supported in
developing design concepts which often started with a conceptual idea of what they hoped to achieve, and through the use of 3D software were able to test out their thoughts before committing to constructing the outcome. Students often come to workshops with a limited amount of cloth, in a sense it is a scarce resource. So they are often reluctant to cut into it without knowing if the design will meet expectations. However, the care they want to take when deciding what to make with it needs to be balanced with learning about possibility. 3D design software enables them to take care of the cloth while being experimental and open to possibility with the design.

4.2. Industry

The linear and siloed nature of the majority of the fashion industry can make the implementation of a holistic process such as zero-waste practice problematic. In interviews conducted with designers who have worked to produce zero-waste designs, McQuillan (2019) notes that a common perspective is that the designer needs to undertake many roles simultaneously and with a high degree of authority. While these issues also arose in the following case study, the use of 3D software facilitated a different level of understanding from the company and designer than in previous attempts.

4.2.1. High price outdoor brand: existing 2D pattern – digital 2D/3d design – sample

In a field test with a high price, outdoor brand, the use of 3D software enabled international collaboration between myself (based in Sweden) and the US-based design/technical team. The software led to a design process (shown in Figure 4) which enabled digital prototyping of a lower-waste design in an industry context, which could then be made into a physical sample.

As the fit of the garment needed to be accurately expressed in the digital prototype, the brand provided a digital fabric sample for use in CLO. This digital fabric sample mimicked the behaviour, texture and expression of the actual fabric, and an accurate lower-waste design was able to be developed digitally. Both digital and analogue samples were made throughout the process – the digital patterns were sent to the design team, and they would construct a sample from the actual fabric. This process proved that the digital version was highly accurate.

The software enables the direct link which already exists between 2D pattern, 3D form and waste produced in garment design to be visualised. The design and technical team involved in the project gained a deep understanding of this intrinsic relationship. It is important to note that the success of this lower-waste design, and the deep understanding of the relationship between design and waste that the design team developed was derailed when a conventional design process was implemented in subsequent steps. The head designer assessed the final physical sample, and changes were made to the design without consideration for the waste generated, as a result the percentage waste reverted to what it was originally. If the industry is to move towards significant reductions in waste, we need to address waste where it is made – in the design process. Therefore tools
such as these, which visualise the design-waste relationship are necessary at every stage of the design-production process.

4.3. Research

In the research context, these digital design tools demonstrate the expansive possibilities of engaging with experimental design research which pushes at the edges of what the software was designed for.

4.3.1. Project name: drape – digitise pattern – digital 2D/3D design – sample

The design process (Figure 5) for Zero + One (McQuillan & Cumming, 2018) involved draping applying Lindqvist’s (2015) Kinetic garment construction method using calico on a dress-form, to produce a garment shell that was not zero-waste, then digitising the resulting pattern and tracing it in the 3D software. The 2D pattern was then digitally modified so that it filled the entire space of the fabric (Figure 6, centre), while simultaneously visualising the outcome (Figure 6, left). The digital 2D/3D design process enabled a direct transformation of the non-zero-waste design into a zero-waste outcome, proving immediate feedback, and the experience was more like sculpture. This pattern could then be printed and a sample constructed (Figure 6, right).


Zero-waste systems thinking (McQuillan, 2019) views the relationship between the broader social and environmental contexts of the industry through a zero-waste lens and responds with a systems-based approach to solving issues that are brought into focus. As a result design practice using this lens approaches the design of textile-forms from a systems perspective – from fibre, up to form, and beyond – the system discussed here is whole garment weaving.

Anna Piper’s, 2019 PhD initially explored the development of whole garment weaving outcomes (Piper & Cumming, 2018). Zero-waste systems thinking (McQuillan, 2019) views the relationship between the broader social and environmental contexts of the industry through a zero-waste lens and responds with a systems-based approach to solving issues that are brought into focus. As a result design practice using this lens approaches the design of textile-forms from a systems perspective – from fibre, up to form, and beyond – the system discussed here is whole garment weaving.
Townsend, 2015). While she discusses the use of digital tools in the context of textile design and weaving (Piper, 2019, pp. 48–61), the focus is primarily on digital production tools (digital looms). She discusses the ‘collapsed’ (Piper, 2019, p. 70) 3D experience when designing in a digital 2D space, and writes of it ‘inhibiting the designer’s instinct to grab, fold, or manipulate the 2D cloth to assess and/or form the 3D structure’ (Piper, 2019, p. 71). In this context, 3D software is invaluable for assisting in understanding and visualising the multiple and changing perspectives necessary when designing for whole garment weaving.

3D software is one in a range of prototyping tools, which also includes analogue processes such as paper, calico toiles, and weaving. The tools together also function to communicate ideas to others involved in the design process, such as textile designers and loom technicians. The design process used is shown in Figure 7. The use of 3D software enabled the development of theoretical zero-waste, whole garment woven designs before an understanding of the required weaving technology was acquired. Using only a foundational understanding of what might be possible on a jacquard loom, design concepts were able to be developed which tested the potential of flattening form for the loom. Digital is not materialised, meaning design practice and research can be more open-ended. The ease of iterating concepts enables a large number of experiments to take place in a relatively short space of time, and as design moves and the assessment of the outcomes of them can co-occur, progress is rapid (Figure 8). Additionally, the software enabled the designs to be resolved to a significantly higher level before physical prototyping, saving time, resources and money.

**Figure 7.** Diagram of a simplified zero-waste design process used for zero-waste whole garment weaving. The use of 3D software enabled the development and visualisation of highly innovative weave-able forms, reducing the risk of wasting time on the loom. Diagram courtesy of Author.

**Figure 8.** Examples of whole garment weaving digital prototypes as developed through Conceptual Idea – Digital 2D/3D design – Fabric Construction – Sample design process. The 2D pattern, 3D form, 2D textile surface and structure are partially or fully developed through this process. Images courtesy of Author.
While translating a digital prototype to garment pattern to physical sample utilising conventional construction methods is straightforward, the translation from digital prototype to woven sample remains time-consuming. It is clear that at this highly experimental edge of fashion and textile practice, there is a need for new digital toolsets that integrate 3D form design and weaving software.

5. Digital 3D design workflow for zero-waste design practice

The eight fashion design workflows that Rissanen articulated (refer to Figure 1) all provide opportunities to consider (or hinder) waste elimination. To augment these existing workflows, this paper suggests a series of additional processes, shown in Figure 9, which have emerged because of the new digital tools available.
Digital 3D design tools primarily replace the Sketch – Pattern – Toile – (Design/Pattern alteration) part of the basic fashion design process and zero-waste fashion design process without 3D tools (refer to Figure 2), with a single holistic process: Digital 2D/3D Design that encompasses all of these. This hybridising of multiple 2D and 3D processes into one, can speed up the development of garment designs, whether zero waste or conventional. However, the interdependence between 2D pattern, waste, and 3D form for zero-waste fashion design means the utility of 3D software is amplified. 3D software provides the designer with a higher degree of certainty that the garment they design in virtual 3D from the zero-waste 2D pattern is the one they produce in real life – with far fewer mistakes and fabric waste in the process.

6. Conclusion

The emergence of accurate 3D software for garments has had a significant impact on the fashion industry in the last five years. While often used for visualisation and marketing, the potential for these tools to transform design practice itself is vast. The advantages of 3D design software to augment the garment design process are clear, and this is particularly true for zero-waste fashion design. Zero-waste design is a hybrid 2D/3D activity, one which ties the 2D pattern powerfully to the 3D outcome through the goal of no waste. Every decision has an impact on both efficiency and expression, so 3D software allows the designer to see in real-time the impact of these decisions.

The use of digital 3D tools opens up new opportunities for the application of zero-waste design practice and articulates new workflows and ways of working. In this paper, I have discussed a range of industry, education and research case studies, to demonstrate ways 3D software has transformed my practice as a zero-waste designer. It has enabled my practice to evolve from mostly creating rough analogue approximations in paper to accurate digital experiments. These case studies are used to propose eight new workflows in addition to Rissanen’s analogue processes that are relevant for zero-waste design practice. Additionally, this paper suggests the development of new digital tools to further support the use of hybrid fashion and textiles practices.

It is clear that for the industry to move towards a significant reduction in waste, it needs to address waste where it is made – in the design process. Therefore, tools such as these – which visualise the form design-textile waste relationship – are necessary at every stage of the design process. By enabling a simultaneous awareness of textile use and design of form, 3D software makes it possible to take care of textile resources while being open to design experimentation. This freedom also provides space for new zero-waste methods that more profoundly integrate the design of textile with the design of form in a truly holistic systems-based approach for the redesign of the industry as a whole.

Notes

1. Creative Practice PhD.
2. Marker making is a (digital or analogue) process that takes the provided garment pattern and seeks to achieve the most efficient layout of the pattern of fabric for production.

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