



Craft practice for sustainability. Re-thinking commercial footwear design process with a woven textile approach

Jenny Pinski^{a,*}, Faith Kane^b, Mark Evans^a

^aLoughborough University, UK

^bMassey University, NZ

*Corresponding author e-mail: J.Pinski@lboro.ac.uk

Abstract: The role of hand processes in design has evolved through history and in the present day, designers frequently employ digital methods. This brings opportunities but can limit material knowledge and it is therefore timely to reflect on the significance of hand processes. This paper explores the potential of craft-based woven textile approaches to designing sandals for large-scale manufacture. It addresses the research questions: what is the current situation/market in footwear/woven textile design; what are the benefits/drawbacks of a hands-on/craft-based approach to footwear design; does the approach have the potential to facilitate improved sustainability and if so, in what capacity? The paper presents findings from a practice-led study and key advantages of a craft-based approach were identified in generating in-depth knowledge of constructions and materials. This led to design outcomes that have potential benefits in sustainability through a zero/low-waste construction. However, the findings indicate difficulties in logistics, timescale and cost efficiency.

Keywords: Design for Sustainability, Practice-led Research, Hands-on Design, Footwear, Woven Textiles

1. Introduction

Hands-on interaction with material leads to the acquisition of knowledge (Cross, 2001, p.54-55; Leader, 2010, p.408; Philpott, 2012, p.56; Sweet, 2013, p.32) and has the potential to facilitate innovation and creativity (Yair and Schwarz, 2011, p.312; Treadaway, 2007, p.35). Wallace and Press (2004, p.44) describe how “craft finds beauty and design puts that beauty to work.” This principle has relevance to this study and the exploration of how the utilisation of craft-based textile processes can promote design for sustainability in the ‘ready-to-wear’ market.

The proposal of an approach that has potential for application in a commercial market is an important aspect of this research, with the potential impact for sustainability being far reaching in comparison to the production of bespoke products or small-scale production runs. An investigation of footwear markets revealed opportunities within the 'ready-to-wear' sandal market. A study of textile manufacturing identified narrow weaving as having the potential to be an appropriate method of production of sandal uppers, with the opportunity to produce single piece woven constructions that could minimise the material waste usually associated with the footwear manufacturing process. In the footwear industry a large amount of waste from excess materials is generated during the production process and around 25-35% of leather and 20-25% of textiles are discarded (Afirm Group, 2010) and so a zero/low waste product could have a positive environmental impact.

Practice-led research in the form of a design project case study revealed a key advantage of hands-on approaches in gaining in-depth knowledge and was supported by the findings of the literature review. Potential was identified in increasing designer awareness through the knowledge gained, thereby providing a catalyst for innovation and sustainable production brought about by a holistic craft-based approach in which form, construction and material are considered in parallel.

2. Products and Markets

2.1 Sandals

Thornton (1970, p.21-23) presents the theory that any modern sandal can be classified in terms of a small number of basic types that are taken from the traditional footwear of different cultures. This is based on the premise that all methods of attaching a sole to the foot have been discovered since the first production of sandals in 3500 B.C. (O'Keefe, 1996, p.22). Schaffer and Saunders (2012, p.132) state the importance for designers to have knowledge of basic types of footwear and reinforce that even the most directional designs are likely to refer back to a traditional style. Therefore, in a woven textile approach, designers will conceivably need to reference and have an awareness of a number of traditional styles. A list combining the categories defined by Thornton (1970, p.21-23) and Schaffer and Saunders (2012, p.132-134) is outlined below.

- Toe-peg/toe-knob
- Toe-band
- V-strap/thong
- Instep-band
- Crossed-band
- T-bar
- Sling-back
- Multi-strap
- Peep-toe

When referring to footwear in terms of a fashion product, three main market categories can be identified: bespoke/haute couture, ready-to-wear and mass-produced (Waddell, 2004, p.ix).

Within the ready-to-wear sector, novel/innovative design and quality are driving factors but, unlike bespoke/haute couture footwear, designs are produced on a mass-scale. This makes them accessible to a wide customer base (Verdu-Jover et al., 2008, p.1881). The mass-produced market is not suitable in terms of timescale and efficiency as emphasis lies in price (Verdu-Jover et al., 2008, p.1881) and speed to market (Cohen, 2011, p.12; Patriquin, 2012, p.41).

2.2 Textiles

Wilson (2001, p.13) divides textiles into two categories: "constructed" and "printed". Constructed is used to describe fabrics that are designed by determining their construction, for example woven or knitted, while printed is used to describe a fabric that has been worked into or embellished to

generate a new design, for example dyed, printed or embroidered. Elsasser (2010, p.137) describes different categories of constructed textiles, grouping them according to how they are made. Fabrics can be constructed from chemical solutions, fibres or yarns and Figure 1 shows the types of material that fall under these categories. An important aspect of material selection for textile design is the consideration of relevant properties of fibres and subsequently the fabric. Glanville et al. (1934, p.103-104) describes the way in which the nature of materials affects design in the field of footwear and the essential balance between creativity and functionality. Schaffer and Saunders (2012, p.136-139) describe the way in which material selection is influenced by fashion trends and suitability for manufacture. Material choice is one of the main ways in which designers have addressed sustainability in textile design (Fletcher, 2014, p.3-4) and interacting with materials at the early stages of the design process has been found to have the potential to increase the designer’s focus on the qualities of a material (Bezooyen, 2014, p.286). In order for textiles to be sustainable, the whole product lifecycle must be considered (Fletcher, 2014, p.5) with the potential for the integration of textile and product design increases awareness of the lifecycle by embedding the material design into the creation of the end product.

Solutions	Fibres	Yarns
Films	Felt	Wovens
Foams	Non-wovens	Knits
		Braids
		Laces
		Knotted
		Stitch-through

Figure 1. A diagram showing categories of constructed textiles as identified by Elsasser (2010, p137).

Textiles can be manufactured using a number of different methods and may be done by hand or using digital technology. Integrated computer aided design (CAD)/ computer aided manufacturing (CAM) systems are common-place in woven and knitted textile production and Grady and Hamouda (1995, p.24) describe how engineering technology for these types of textile manufacture lead the way in terms of utilising CAD/CAM. Woven fabrics are commonly fabricated on a loom, this piece of equipment is central to the construction process and exists in a number of different forms (Elsasser, 2010, p.141).

Narrow fabrics are woven textiles that are produced in narrow widths. From the mid 1600s it has been possible to produce several woven tapes on a single loom in a process that can now be mechanised (Thompson and Dick, 1952, p.14). This makes it a viable method of production for the ready-to-wear market where designs are produced on a large scale (Verdu-Jover et al., 2008, p.1881). The narrow width of the fabric also makes it applicable to sandal design. A number of structures can be achieved using narrow weaving and different classifications of narrow fabric, as

identified by Posselt (1917) and Thompson (1952), are shown in Figure 2. Some of these structures have been identified by the authors as having potential for use in sandal upper construction as follows:

1. Open structures and leno – Sandals have an upper which exposes the foot and so open work has potential to be utilised
2. Multiple cloths - It is common for sandals to have multiple straps and so multiple cloths may be used in this way
3. Figured - Extra threads can be trapped in a figured weave, these could create straps while also providing potential for the introduction of pattern

The way in which a loom is set-up is dependent on the desired weave structure, therefore analysing relevant structures is not only important when considering manufacture but it provides design inspiration through the imposition of technical parameters. This can aid creativity by allowing the designer to focus on the possibilities of what might be achieved within the necessary constraints (Shillito et al., 2001, p.199). Additionally, this example demonstrates the way in which hands-on woven textile designers must possess an awareness of and consideration of construction from the beginning of the design process.

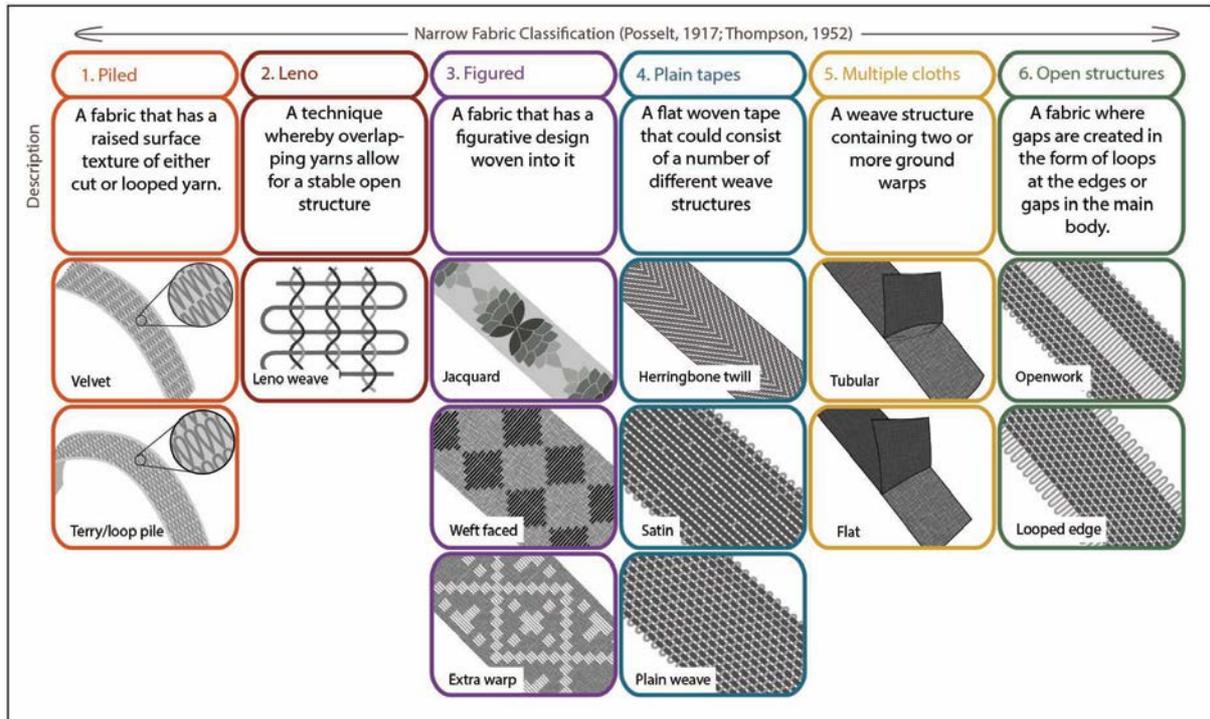


Figure 2. A taxonomy of narrow fabrics

3. Design Processes

Design is a decision-making process, using creative problem solving (Collis et al., 2007, p.2) to realise ideas, transform them into products (Wilson, 2001, p.13) and generate a solution to a design problem (Lawson and Loke, 1997, p.8). It is an activity that can become highly complex and there is a need for structure within it. Such structures often relate to the requirements and deadlines of an organisation (Tovey, 1997, p.13). Wilson (2011, p.58) developed a design process model and outlined the main activities as being: need/requirements, research, ideas generation, design development, design realisation/finished design, and evaluation (see Figure 3). Although designers do not

necessarily follow a formal model, there are common elements (McDonagh-Philp and Lebbon, 2000, p.32) and innovation can occur when creative thinking is applied to existing knowledge and processes (Collis et al., 2007, p.3). The general design process is interdisciplinary (Wilson, 2011, p.57) and it is not uncommon for designers to experiment in disciplines outside of their own, which is a way in which innovation may occur (Lawson and Loke, 1997, p.7). While the researchers acknowledge that the design process is a personal activity and is not linear, in the context of this research, the division of the design process into stages based on the purpose of the activity has aided the qualitative analysis of the case study data.

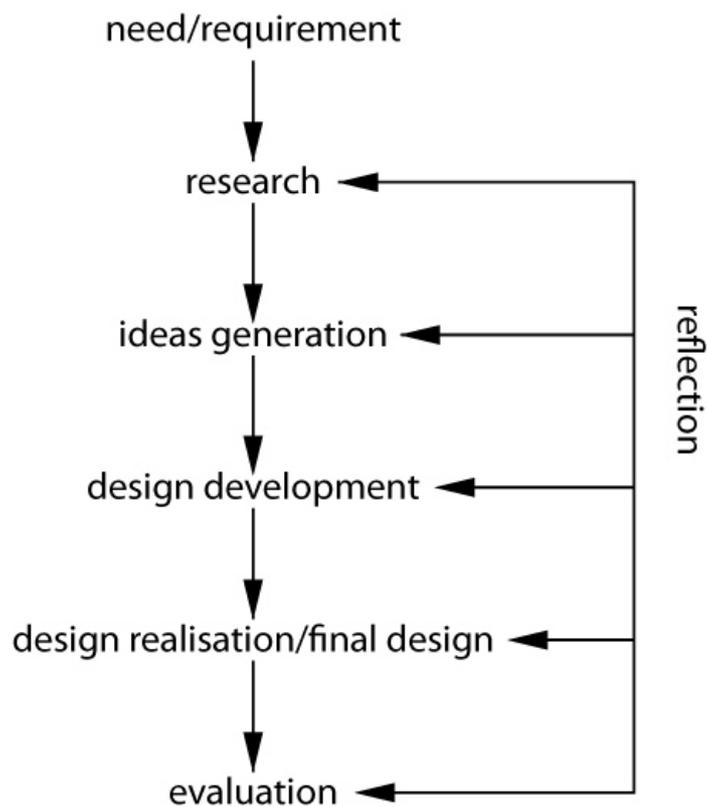


Figure 3: Design process model (Wilson, 2011, p.58)

3.1 Footwear Design Process

The footwear design process has a number of possible approaches and, as with the general design process, it is not linear. Different companies/designers approach it in a variety of ways depending on product type, market and personal preferences (Wilson, 2001, p.19-20). This section focuses on design for manufacture as opposed to designer-makers, where the final design is also the finished product (Schaffer and Saunders, 2012, p.157). Footwear design requires a balance of creativity and functionality (Glanville et al., 1934, p.103); it “combines a full spectrum of concerns,” and a successful design is “both an appealing object and a feat of engineering” (Huey and Proctor, 2007, p.165). With such complex products, accuracy and detail is key (Schaffer and Saunders, 2012, p.121) and this is reflected in the design process. The early stages of footwear design are commonly undertaken through drawing, either by hand or using digital software such as Adobe Photoshop (Schaffer and Saunders, 2012, p.150; Joneja and Kit, 2013, p.214). The shoe last¹ is also generally designed/selected at an early stage as it has a significant impact on the look of the shoe (Glanville et

¹ A foot shaped that mould determines the shape of a shoe

al., 1934, p.104). In the development stages of the process, the designer generally creates specification sheets (Schaffer and Saunders, 2012, p.156-159) so that the manufacturer can undertake rounds of sampling, before a final product is signed-off (Sterzing et al., 2013, p.611). So, generally, except in the case of designer/makers, footwear designers will have very little 3D hands-on interaction with the product or materials.

3.2 Textile Design Process

Wilson (2001) presents a comprehensive overview of the textile design process, where the main function is described as, to “design and produce, to an agreed timetable, an agreed number of commercially viable fabric designs” (p.10). The design process is usually one of intuition, based on experience and there is a certain amount of trial and error (Adanur and Vakalapudi, 2013, p.716). However, in the discipline of woven textiles, while there is an opportunity to generate unexpected results on the loom (Wilson, 2001, p.15) a great deal of planning is relied upon (Bate and Rudman, 2014). Weavers must work within the constraints of the warp whilst using creativity, intuition and judgment to make decisions (Hemmings, 2012, p.7). In woven textile design, inspiration may be gathered from a wide range of sources (Clarke, 2011, p.170) and design ideas may or may not be drawn prior to sampling. Once the concept has been identified and initially researched, it is possible to determine some of the details required in order to progress with generating design ideas. This includes the colour palette, which is generally an evolution of a current palette developed in response to colour trends (Wilson, 2001, p.15; Clarke, 2011, p.178-180). Once the colour palette has been developed, materials can be chosen, for example, in woven textile design this is the stage when suitable yarns would generally be identified (Wilson, 2001, p.15). In hand-woven textile design, specification sheets are required in order to begin to generate design ideas on the loom, they provide the details needed to set up the equipment and then begin weaving (Shenton, 2014, p.10). Designs are often made by hand, initially in the form of small “sample blankets” (Wilson, 2001, p.15) that test yarns, colour and structure before moving on to larger development samples. It is therefore more likely that the textile designer will engage in hands-on interaction with materials in comparison to the conventions of footwear design.

4. The application of craft-based textile approaches and sustainability

In the field of architecture, Oxman (2012) reports on an increasing interest in the role of materials in design and presents a theory of “informed tectonics” where there is a relationship between design, material and structure. This method of design is likened, by Oxman, to vernacular crafts such as weaving and describes how the logic of such crafts can be extended for use within design disciplines. This way of thinking can incorporate the utilisation of digital design and construction methods by considering design, fabrication, production and manufacturing in parallel and thereby employing craft-based principles within digital processes (Oxman, 2012, p.450). Khabazi (2010) has developed generative algorithms to design 3D digital structures based on woven textiles. Which, as with Oxman’s theory of informed tectonics, has potential for applications in the field of architecture. However, it is arguable that the generation of digital woven structures does not provide the designer with the same depth of knowledge and understanding as hand processes.

The concept of an informed relationship between materials and design is reflected in a theory of “materials driven design” developed by Bezooyen (2014). This is an approach in which materials are introduced at the early explorative stages of the design process. Initial findings indicate that in using this approach, “designers are more focused on thinking about surfaces, structures, colors, and

sensorial qualities in their idea generation” (Bezooyen, 2014, p.286). Such qualities are commonly recognised as being important at the early stages of the woven textile design process (Wilson, 2001, p.14-15). Another example of the use of woven textile principles in other disciplines is the development of “a loom that weaves in three dimensions,” by design engineers who have combined the concepts of woven textiles with 3D printing to enable novel methods of creating 3D structures. This loom has the potential for use within the medical, architectural, automotive, aerospace and sportswear industries. Structures can be engineered according to the desired characteristics of the material (Magee, 2014), as is the case in woven textiles (Elsasser, 2010, p.143-159).

In addition to the application of craft-based textile design approaches to other disciplines, constructed textile designers are also considering and designing directly for end products or applications such as architecture and fashion. Designer Lucy McMullen creates 3D structures using woven textiles, thinking of weave as more than a method of creating fabric and notes its potential for use in engineering and architecture (Hemmings, 2012, p.65). Constructed textile design is currently being used in footwear but, due to the secretive nature of the industry, it is rarely written about, thereby limiting available information to patent applications and marketing material. An example is the Nike Flyknit, a running shoe with a knitted upper that was developed over a period of four years. The knitted construction of the upper claims to have benefits in performance, weight, form and sustainability (Nike, 2012). This is an example of how in-depth exploration of materials and construction can aid innovation, provide multiple benefits and enhance commercial appeal. Similar approaches are used in the fashion industry in the design of fully fashioned knitwear where garment panels are knitted to shape (Wilson, 2001, p.103). As the panels are made to the correct shape little or no waste is generated and the concept of reducing waste through more informed design decisions is an area of concern for both designers and researchers and it is an area to which this research contributes. This is being approached in a number of different ways, with Rissanen and McQuillan (2016) presenting a pattern cutting approach whereby designers create garments fashioned from a whole piece of fabric with no waste generated through offcuts. Niinimäki (2013) discusses zero waste fashion design where the textile process informs the garment. Aspects such as the width of the fabric and its properties are considered and it is concluded that where the designer creates their own fabrics, potential for novel outcomes is increased. Piper and Townsend (2016) build on this theory in their development of a “Composite Garment Weaving system” (p.4) whereby items of clothing are designed using woven textile approaches and methods allowing them to be woven as a single piece. This integration of woven textile and fashion design demonstrates a similar approach to that explored in this paper, with applications in a different discipline. Piper found that by designing the material and product in parallel there may be associated environmental benefits by engineering garments to minimise waste in production (Piper and Townsend, 2016, p.7).

The application of craft-based logic in the creation of an informed and holistic design process is a key area of investigation for this research. Some of the examples discussed incorporate digital methods into craft-based approaches and the integration of CAD/CAM may aid its application in a commercial design and manufacturing context where a number of constraints must be considered. For example, Oxman (2012) describes the way in which CAD/CAM can be utilised in order to employ such logic and it is conceivable that in order to make the processes developed during this study applicable to industry, they may need to be integrated with digital approaches. However, in order to develop digital systems, the physical processes must be practiced to understand them more fully (Philpott, 2012, p.61). Additionally, designers may not experience the same levels of knowledge gain and control when using digital methods.

5. Approaches to a hands-on textile-based design process

To investigate a craft-based approach to sandal design, an action research case study was undertaken in the form of a design project in which sandal uppers were created through the medium of hand woven textiles. Data collection was carried out through recording diary entries at the end of a day of designing (Pedgley, 1997, p.220-221) and data analysed through coding and clustering (Dey, 1993; Eisenhardt, 2002).

Tasks were categorised independently of the outcomes/consequences/what was involved and the relationship/links between them investigated. Tasks were assigned to a stage of the design process and then divided by the type of approach used. The approach referred to whether they were 2D or 3D and digital, non-digital or hybrid², thereby allowing the process to be investigated in terms of these categories. The second stage of categorisation involved the outcomes/consequences/what was involved. It included the labels of “material/physical understanding” and “focus/inspiration/exploration” among a number of others relating to the data. They were categorised and linked to the approaches used. Three types of link were identified, led to/provided/aided, involved/used and informed. It was possible to apply these links to the majority of the data, thereby viewing them in relation to one another. This paper focuses on two stages of the design process outlined by Wilson (2011, p.58): the “research” and “ideas generation” stages. These were the two main areas addressed within the pilot study, with the “need/requirement” stage having taken place before the case study commenced and the latter stages being areas of on-going research. During the research stage three different approaches were used:

- 2D digital
- 2D hybrid
- 3D hands-on

2D digital approaches included the creation of digital inspiration/mood boards. This aided the development of a theme and provided focus and direction for the product to be designed. It also provided inspiration, informing subsequent stages of the design process. With large amounts of imagery readily available online, initially this led to excess information but also provided efficiency. Figure 4 shows an example of an outcome in the form of a digital mood board.

² Hybrid in the sense of using digital and non-digital methods in conjunction with one another



Figure 4. Example of a 2D digital research outcome

2D hybrid approaches were utilised to generate and refine a colour palette. The non-digital aspects provided benefits in accuracy of shade/tonne but sometimes lacked time efficiency. Digital methods were integrated to improve efficiency, however, this impacted on accuracy. 3D hands-on research was initially used to explore potential yarns, involving testing and decision-making through tacit judgment to gauge the suitability of materials. As discussed in Section 3, stages of the design process may be revisited and this took place in the case study. Towards the latter stages, nylon yarns were tested through weaving and finishing processes. An understanding of the behaviour of potential materials was gained to inform future work. It also highlighted the potential for hands-on processes to be used to explore materials, providing inspiration and potential for innovation through exploiting the properties of those materials. This represented evidence of the designer taking a considered and informed approach. Along with these insights, data analysis revealed that the most prominent function of 3D hands-on research was ‘material/physical understanding’, contrasting with the two other approaches, both being ‘focus/inspiration/exploration’.

The idea generation stage also revealed some insights. This stage of the design process consisted of three approaches:

- 2D hybrid
- 3D hands-on
- 2D non-digital

2D hybrid idea generation involved drawing. Sketching was used to perform the more intuitive aspects and CAD was introduced where higher levels of accuracy were needed. An example of a CAD template that has been sketched into, alongside a sandal design (also sketched) is shown in Figure 5.

3D hands-on idea generation was undertaken using two methods: model making with paper and

weaving on six-shaft floor loom (see Figure 6). Model making aided idea generation, planning and visualisation, it was time and cost efficient. However, as it was representational it did lack in the generation of in-depth knowledge of materials. In some instances, weaving was used to visualise and evolve design ideas that had been conceived using 2D approaches. On the loom, the construction and materials could be understood in more depth. In some cases, ideas were generated on the loom with some designs inspiring future ideas. These evolutions were either trialed straight away on the loom or quick models were made on the last in order to provide measurements for weaving. During the case study, concerns arose over the effective presentation of 3D uppers with 2D sole designs. The sketches generated using 2D approaches were not accurate due to the designs evolving on the loom and they were not presentable. In order to address the issue, the uppers were photographed on a clear vacuum form of a last before being digitally placed onto the outsole design (see Figure 7). This digital approach was integral in bringing the designs together for coherent presentation.

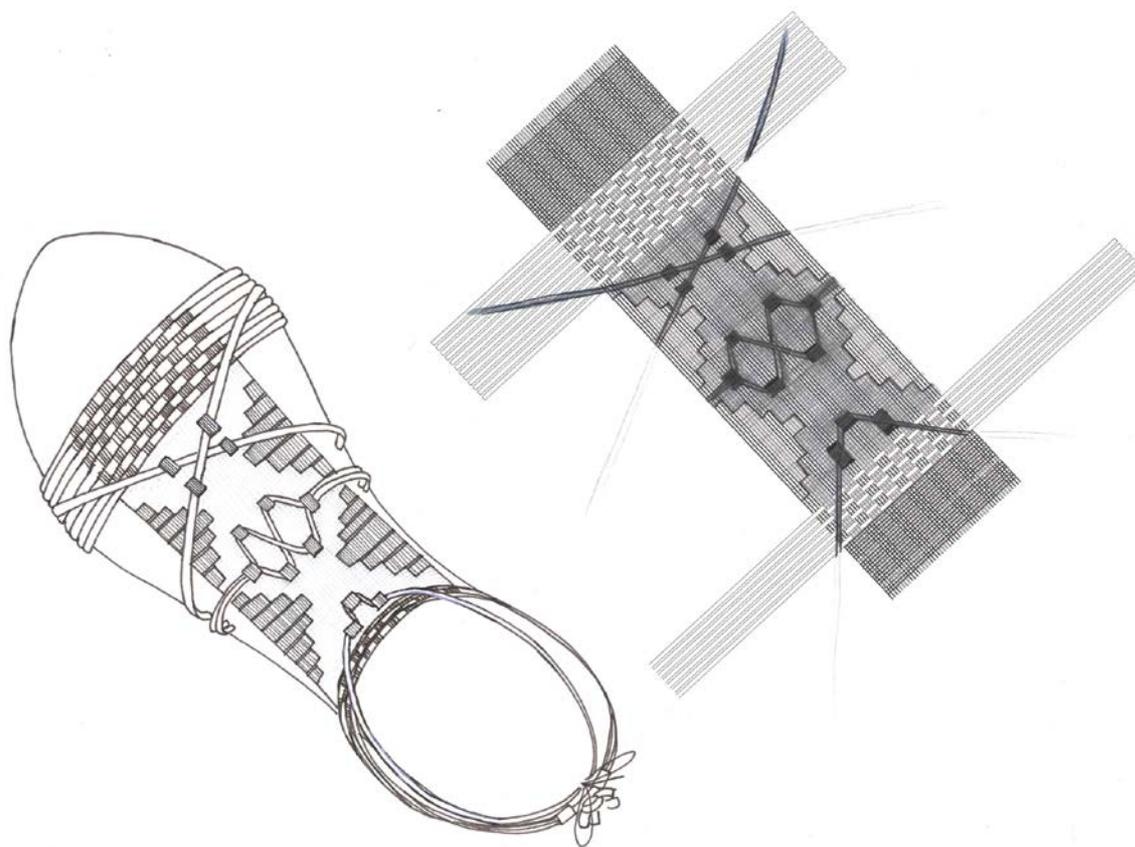


Figure 5. Example of a non-2D digital and hybrid design outcome

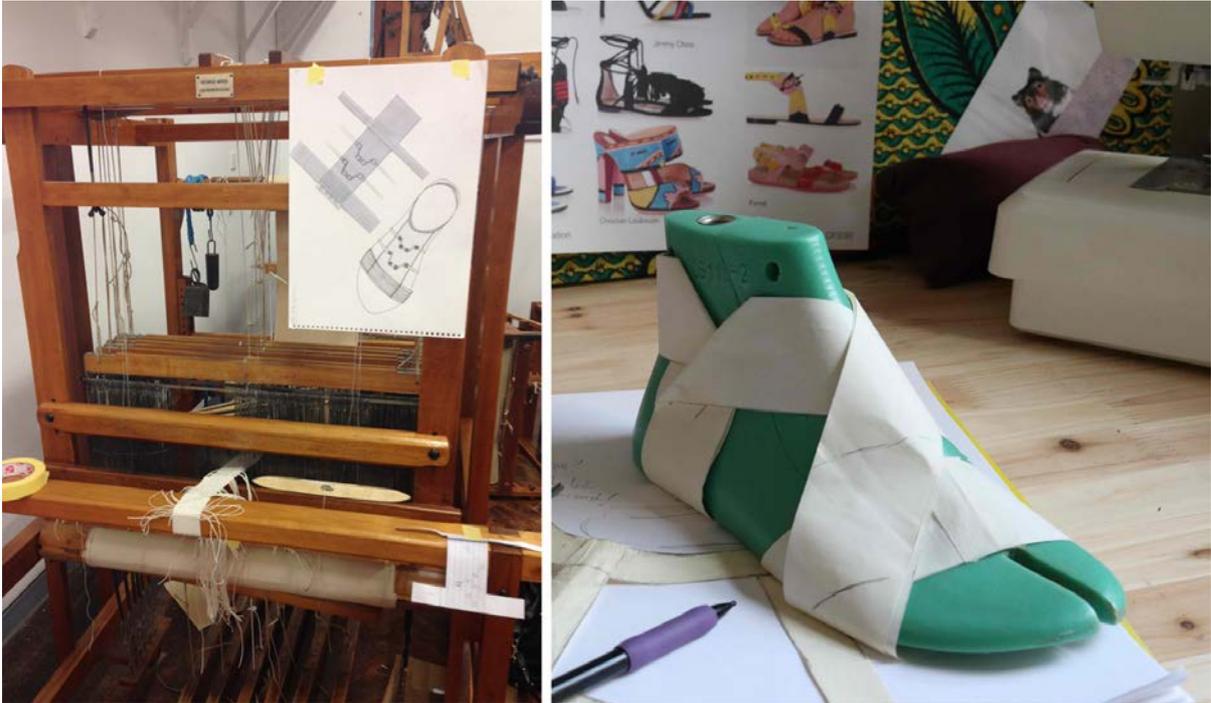


Figure 6. Examples of 3D non-digital design processes including paper modelling and sampling on a 6 shaft floor loom



Figure 7: 3D upper and 2D sole brought together for presentation using digital software

6. Conclusions

Craft-based processes explore form, construction and material as a single process whereas typical methods of footwear design explore them sequentially. Although these stages may be revisited, as Schaffer and Saunders (2012) describe, they are generally performed as separate actions. Figure 8 shows these approaches in relation to one another. This logic may be implemented through digital methods although the same benefits may not be seen with regards to innovation and knowledge gain. In addition to knowledge and innovation, the literature review revealed that a craft-based textile approach to design provides potential for improvements in sustainability. Designing materials and products in parallel can allow for materials to be constructed to the size and shape needed and therefore reduce waste. Empirical evidence revealed the potential in sandal design through the generation of uppers that can be woven as a single piece.

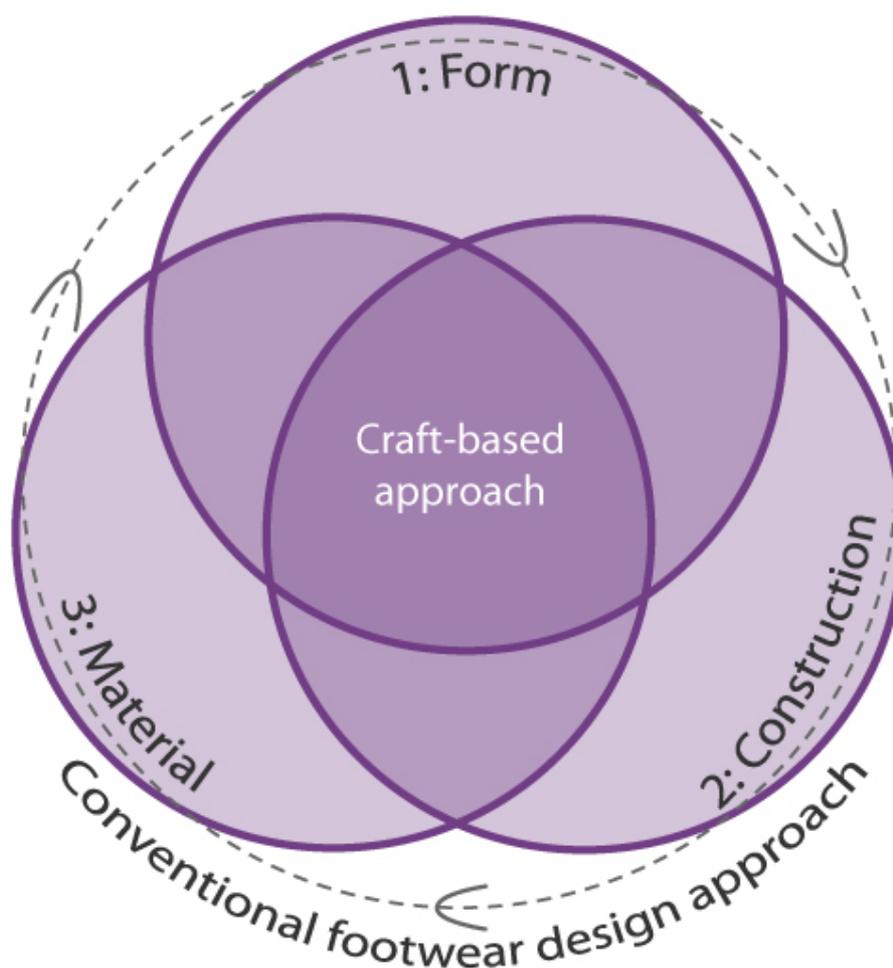


Figure 8. A Venn diagram showing a craft-based approach in comparison to more typical footwear design

It has been identified that a craft-based approach is applicable under some, but not all circumstances. Where innovation and sustainability in relation to construction and materials are important, it can be argued that hands-on design methods provide benefits. The introduction of automated manufacture would mean that there is the potential to produce woven textile sandal uppers on a large scale and, due to high levels of automation, production would not be restricted to countries where labour costs are low in order to be competitive. This could lead to a viable approach to 'on-shore' production in countries where the product is to be distributed and therefore reduce the environmental impact of shipping products from other parts of the world. A Hands-on approach has been identified as having the potential to aid creativity which could impact positively on the sandal

industry in the form of economic growth (Lommerse et al., 2011, p.388). The ability to apply zero waste design generated via a craft-based approach on a large scale would mean that the benefits could have a far-reaching impact.

Initial findings suggest that the main benefits of hands-on approaches lie in providing an in-depth knowledge of constructions and materials. Therefore, there is an opportunity for future work to consider the impact of this on innovation for sustainability through this increased knowledge, understanding and consideration of product form, construction and materials in parallel. There is the potential for collaboration between designer and craft practitioners, providing a commercial outlet for their work and giving design teams the knowledge and experience needed in order to execute innovations within a craft-based medium. In light of the potentiality discussed in this paper, further research is needed in order to consider different approaches to sustainability, including but not limited to, zero-waste production, local and socially ethical production, longevity and disposal. Additionally, due to the flexibility in of the production process, there is potential for the further research into the development of an on-demand system using digital co-design approaches and modular footwear components.

References

- Adanur, S., & Vakalapudi, J. S. (2013). Woven fabric design and analysis in 3D virtual reality. Part 1: computer aided design and modeling of interlaced structures. *Journal of the Textile Institute*, 104 (7), 715–723.
- Afirm Group. (2010). *Waste Management in Footwear*. Retrieved October 18, 2016, from <http://www.afirmgroup.com/hongkong/17%20Hengstmann%20Waste%202010.pdf>.
- Bate, G., & Rudman, D. (2014). *Artist: Anastasia Azure, Providence, Rhode Island, USA*. Retrieved January 16, 2014, from http://www.worldofthreadsfestival.com/artist%5C_interviews/%5C%046%5C_anastasia%5C_azure%5C_12.html.
- Bezoooyen, A. (2014). Materials Driven Design. In E. Karana, O. Pedgley, & V. Rognoli (Eds.), *Materials experience: fundamentals of materials and design* (pp. 277–286). Oxford: Butterworth-Heinemann.
- Clarke, S. (2011). *Textile Design*. London: Laurence King.
- Cohen, A. M. (2011). Fast fashion: Tale of two markets. *The Futurist*, 12–13.
- Collis, A., Hiley, A. and Wilson, J. A. (2007) Through the wardrobe: a generic platform to foster the evolution of creative problem solving skills, presented at Creative Conference 07: Creativity or Conformity? Building Cultures of Creativity in Higher Education, Cardiff, 2007. Cardiff: Cardiff Metropolitan University, 1–6.
- Cross, N. (2001). Achieving pleasure from purpose: the methods of Kenneth Grange, product designer. *The Design Journal*, 4(1), 48–58.
- Dey, I. (1993). *Qualitative data analysis a user-friendly guide for social scientists*. London: Routledge.
- Eisenhardt, K. M. (2002). Building Theories From Case Study Research. In M. Huberman, & M. B. Miles (Eds.), (pp. 5–35). *The Qualitative Researchers Companion*. London: Sage Publications.
- Elsasser, V. H. (2010). *Textiles: Concepts and Principles*. 3rd. New York: Fairchild Books.
- Fletcher, K. (2014). *Sustainable fashion and textiles: design journeys*. 2nd. London: Taylor and Francis.
- Glanville, F. Y., Worswick, B., & Golding, F. Y. (1934). *Boots and shoes: their making, manufacture and selling, Vol.1: Pattern cutting and making*. London: Pitman.
- Hemmings, J. (2012). *Warp & weft: woven textiles in fashion, art and interiors*. London: Bloomsbury.
- Huey, S. & Proctor, R. (2007). *New shoes: contemporary footwear design*. London: Laurence King.

- Joneja, A. and Kit, F. S. (2013). Computer-Aided Design of Footwear. In R. S. Goonetilleke (Eds.), *The Science of Footwear* (pp. 213–260). Boca Raton: CRC Press.
- Khabazi, Z. (2010). *Generative algorithms concepts and experiments: weaving*. Retrieved December 11, 2013, from <http://www.grasshopper3d.com/page/tutorials-1>.
- Lawson, B., & Loke, S. M. (1997). Computers, words and pictures. *Design Studies*, 18(2), 171–183.
- Leader, E. (2010). Materializing craft: Evaluating the effects of experiencing actual materials during the design process. *Design Principles and Practices*, 4(4), 405–418.
- Lommerse, M., Eggleston, R., & Brankovic, K. (2011). Designing Futures: A Model for Innovation, Growth and Sustainability of the Craft and Design Industry. *Design Principles and Practices*, 5(4), 385–404.
- Magee, T. (2014) *The Structure of Protection*. Retrieved July 15, 2014, from <https://www.prote.in/en/feed/2014/07/the-structure-of-protection>.
- McDonagh-Philp, D., & Lebbon, C. (2000). The emotional domain in product design. *The Design Journal*, 3(1), 31–43.
- Niinimäki, K. (2013). A Renaissance in Material Appreciation: Case Study in Zero Waste Fashion. *Journal of Textile Design Research and Practice*, 1(1), 77–92.
- Nike (2012). *Nike Engineers Knit for Performance*. Retrieved March 16, 2013, from <http://nikeinc.com/news/nike-flyknit>.
- O’Keeffe, L. (1996). *Shoes: a celebration of pumps, sandals, slippers and more*. New York: Workman.
- Oxman, R. (2012). Informed tectonics in material-based design. *Design Studies*, 33(5), 427–455.
- Grady, P. L., Mock, G. N., Clapp, T., & Hamouda, H. (1995). Computer Aided Manufacturing in the Textile Industries. In Berkstresser, G. A., Buchanan, D. R., & Grady, P. L. (Eds.), *Automation in the Textile Industry: From Fibres to Apparel* (pp.19-33). Manchester: Textile Institute.
- Patriquin, M. (2012). One shoe after the other: how Montreal-based Aldo built a sprawling, ruthlessly efficient footwear empire. *Maclean’s*, 125(43), 41–42.
- Pedgley, O. F. (1997). Towards a method for documenting industrial design activity from the designer’s perspective. Presented at IDATER 97, Loughborough, 1997. Loughborough: Loughborough University Department of Design and Technology, 217–222.
- Philpott, R. (2012). Crafting innovation: The intersection of craft and technology in the production of contemporary textiles. *Craft Research*, 3(1), 53–74.
- Piper, A., & Townsend, K. (2016). Crafting the Composite Garment: The role of hand weaving in digital creation. *Journal of Textile Design Research and Practice*, 3(1-2), 3–26.
- Posselt, E. A. (1917). *Hand books of the textile industry, vol. 2: Narrow woven fabrics*. Philadelphia: Textile Publishing Company.
- Rissanen, T. & McQuillan, H. (2016). *Zero Waste Fashion Design*. London: Fairchild Books.
- Schaffer, J. & Saunders, S. (2012). *Fashion design course. Accessories: design practice and processes for creating hats, bags, shoes and more*. London: Thames and Hudson.
- Shenton, J. (2014). *Woven Textile Design*. London: Laurence King.
- Shillito, A. M., Paynter, K., Wall, S., & Wright, M., (2001). ‘Tacitus’ project: identifying multi-sensory perceptions in creative 3D practice for the development of a haptic computing system for applied artists. *Digital Creativity*, 12(4), 195–204.
- Sterzing, T., Lam, W. K., & Cheung, J. T. M. (2013). Athletic Footwear Research. In Goonetilleke, R. S. (Eds.) *The Science of Footwear* (pp. 605–622). Boca Raton: CRC Press.
- Sweet, T. (2013). Instilling an awareness of phenomenology through a craftcentered design pedagogy. *International Journal of Design Education*, 6(2), 31–39.
- Thompson, A. & Bick, S. (1952). *Narrow fabric weaving*. Manchester: Harlequin Press.

- Thornton, J. H. (1970). *Textbook of footwear manufacture*. 3rd. London: Butterworth and Co.
- Tovey, M. (1997). Styling and design: intuition and analysis in industrial design. *Design Studies*, 18(1), 5–31.
- Treadaway, C. (2007). Digital crafting and crafting the digital. *Design Journal*, 10(2), 35–48.
- Verdu-Jover, A., Gomez-Gras, J. M., Mira-Solves, I., & Martinez-Mateo, J. (2008). Alternative value creation strategies in the footwear industry: Exploring the role of production offshoring. Presented at IEEE International Conference on Industrial Engineering and Engineering Management, Singapore, 2008. Singapore: IEEE, 1880–1884.
- Waddell, G. (2004). *How fashion works: couture, ready to wear and mass production*. Oxford: Blackwell Science.
- Wallace, J., & Press, M. (2004). All this useless beauty: the case for craft practice in design for a digital age. *The Design Journal*, 7, 42–53.
- Wilson, J. A. (2001). *A Handbook of Textile Design: Principle, Process and Practice*. Cambridge: Woodhead Publishing.
- Wilson, J. A. (2011) *Core Design Aspects*. PhD thesis. The University of Manchester.
- Yair, K., & Schwarz, M. (2011). Making value: Craft in changing times. *Cultural Trends*, 20(3-4), 309–316.

About the Authors:

Jenny Pinski is a Lecturer in Textiles at Loughborough University and her current research is informed by her professional experience in footwear and textile design. More broadly she is interested in the areas of craft-based design and practice-based methodologies.

Faith Kane is a senior lecturer at Massey University, NZ. Her research interests include textile and materials design for sustainability, collaborative working in the design/science space and the role of craft knowledge within these contexts, details can be found at faithkane.com.

Mark Evans is a Reader in Industrial Design with a practice-informed research profile that, in addition to journal publication, has generated impact beyond academia through web site, app, video, patent, pdf download, exhibition, cards and design award. He has supervised/examined 29 PhDs.

Acknowledgements: this section is optional. You can use this section to acknowledge support you have had for your research from your colleagues, student's participation, internal or external partners' contribution or funding bodies.