

Fluid Materialities: Physical and digital modes of textile making

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New processes of textile making that involve both physical and digital dimensions, and the conceptual implications of these new materialities, are the focus of the research discussed in this paper. Through a consideration of recent theoretical framings, technological infrastructures and experimental processes of making, contemporary textile design is addressed in terms of materiality, mediation and embodiment and their social and aesthetic implications. The relationships between new textile surfaces, new frameworks and the new sensibilities produced through these technological infrastructures (Thrift 2005) are explored in light of the transformative potential of materials within which technology is embedded (Küchler 2008).

Part One: Theoretical Framings

The nature and role of textiles as a 'second skin' has been widely acknowledged (Flint 2012; Jefferies et al. 2015). More recently the notion of skin as a sensory interface or 'fringe of the virtual' (Hansen 2006) has been proposed through digital embodiment theories. Daniel Miller (2005) has recognised the longstanding distinction made between the material and immaterial constitution of culture and society in western thinking. He has called for a reconsideration of such subject /object frameworks based on 'mediation' through new forms of 'technological materiality'. The implications of these ideas to the making and meaning of contemporary textiles warrants further consideration.

Nigel Thrift (2005) suggests that relationships between new surfaces, new frameworks and new sensibilities are produced through 'technological infrastructures'. Traditional textile industry models which separate design, production and consumption are challenged by these new infrastructures and need to be reviewed (Küchler 2008) in light of these new technological materialities and associated cultural and methodological shifts.

These theories of materiality and embodiment inform three case studies which discuss the work of three textile designer/researchers who are engaged with different digital and physical textile making processes. Each case study is considered in relation to one of Thrift's three frames or registers - screen, software and body, which he proposes as 'different forms of reanimation of the world' involving 'the active mediation of machines of various kinds.' (Thrift 2005: 232).

Thrift suggests that these three frames or technological mediations he identifies produce 'a new set of surfaces gradually covering the world, a kind of second skin of new forms of attention,' (ibid: 233) that are deeply interfused. The first register is the screen, where the establishment of an 'ecology of screens' in contemporary Western societies has become a 'vast epistemic apparatus and a new form of inhabitation' (ibid: 233–234). The second register is software, an invisible, written, 'technical substrate' which 'intervenes in nearly every aspect of everyday life and has become part of the taken for granted.' (ibid: 240). Thrift notes that software is not just an intermediary, but is an agent of 'material complexification,' with a theoretical background that is 'often sunk into the interstices of the code itself' (p.244).

The third register is the human body, 'thought anew', where the body forms a new set of informational surfaces which, through the combination of machine and theory, create a new 'inside' which is also simultaneously an 'outside.' These framings and associated textile practices can be considered to extend beyond established systems of production to contest traditional subject/object relationships and notions of corporeal integrity that have been essential to modernist conceptualisation of human being.

The first case study references a project by Miranda Smitheram, Dematerializing Fashion: Print and Surface Remediation, which examines the materiality of the digital image reinterpreted through Motion Capture and 3D animation into virtual artefacts and digitally printed textiles. Visually the surfaces display unique hallmarks of their transference across physical-digital dimensions, mediated through screens onto both physical and virtual textile surfaces. Multi layered images, glitches, data bending and 3D elements suggest a particular aesthetic emerging through the oscillation between digital and physical processes of making.

The second case, Technic and Aesthetic in 3-d Knitted Form by Jyoti Kalyanji, references on-going research into the possibilities in the design and application of knitted textiles. By displacing advanced digital seamless knit technology from its intended industrial knitwear environment and overcoming software limitations, underpinned by established knitwear industry conventions, the project explores novel three-dimensional knitted forms as pliable, textural skins for a range of objects, not just for the body. Accessing this capability requires new skills, language and approaches as the textile practitioner mediates between seemingly abstract and disconnected interfaces from three-dimensional design concepts, digital interfaces in the form of two-dimensional grids, and the physical textile artefact with its embedded shape, textural, visual aesthetic and materiality.

The third case, Sapient Materiality: e-Textiles and Embodiment by Frances Joseph, considers the mechanics of stitch and yarn structures and their electronic capabilities to investigate new understandings of embodiment through a digital materiality. The project explores the field of knitted e-textiles where digital materiality is embedded within the physical artefact. Here the particular material and mechanical properties of yarn and stitch structure and the electronic performance of the textile are intertwined.

This new medium requires an understanding of both digital and textile process which are brought together, opening up new possibilities for 'flexible, wearable, washable computers' (Dias 2013) as sensing, responsive textile skins produced through new hybrid forms of digital and textile making, and forming new relationships to the body.

These three projects map flows between experiential dimensions of traditional textile production and approaches to making with digital technologies. The intersection of material knowledge with digital processes not only has future economic significance, but has profound philosophical implications. This paper engages with new frameworks that offer a means of understanding the interfaces and potential of these new textile surfaces and practices.

Part Two: Case Studies

Case Study One: Dematerializing Fashion: Print and Surface Remediation

The first case study explores digital print and surface remediation. The process uses the materiality of the digital image reinterpreted through 'pre' and 'post' 3D technologies of motion capture and animation into virtual textile artefacts which are then transferred into other states, for example through physical printing on textiles or as simulated digital cloth animations. This project extends ideas of surface, imagining a future where clothing could become a morphing digital canvas. The surface designs iterate across registers of actual, digital and virtual.

In this design process, motion capture is used to track synchronistic human movement. This motion then becomes the scaffolding and base for transforming ambiguous textiles, with realistic movement driven by the motion-captured data. The surface designs for the textiles are developed from imagery that transfers across states, beginning as digital photograph, developed in Photoshop, and then applied to the motion-captured physical body as a reimagined morphing surface. In some iterations the final resolved state is an animation of the transforming surfaces, whilst in other iterations the final state is a digital textile print.

Visually the surfaces reveal unique hallmarks of their transference across physical-digital dimensions. The resulting artworks display meta-textual effects from the transliteration between different materialities. Aspects of physicality are evident in the traces of human movement in the motion-captured data, whilst suggestions of digital process are evident with screen and programming software imposing particular visual implications due to inbuilt functions and toolbox options. The work references its hybrid artefactual origins with multi-layered images, glitches, data bending and 3D elements suggesting a specific aesthetic emerging through the flux between digital and physical modes of making.

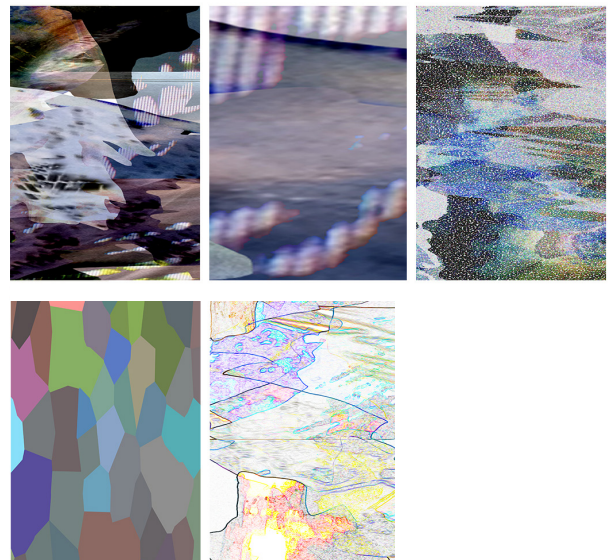


Figure 1 Selected images from *The Liminal Dress* sequence (M Smitheram, 2015).

In the example given in Figure 1, a static digital image sequence is developed that will later become a morphing surface. Firstly, digital photographs are collaged, and the images taken through a series of digital design processes. Gradually, through shifts in scale and the micro becoming macro, pixellation and technical features create the exterior surface. This process relates in particular to Thrifts' concept of 'screenness', where he defines this register as a material state in which the technical rises to the surface and becomes the exterior (Thrift 2005).

The materiality of the digital image is also reinterpreted through physical printing, whereby the technology of the digital becomes manifest through printing.

Unique digital cues such as pixellation and refraction (figure 2) also evidence 'screenness'. Thrift describes the changing nature of technological materiality as the result of new infrastructures that question our usual concept of mediation because they are neither 'inside' nor 'outside' but are the work of mediation itself (Thrift 2005). This suggests that a sense of a new materiality comes not just from working across one modality to the next, but rather results from the specific actions and processes in the entwinement of physical-digital modes.

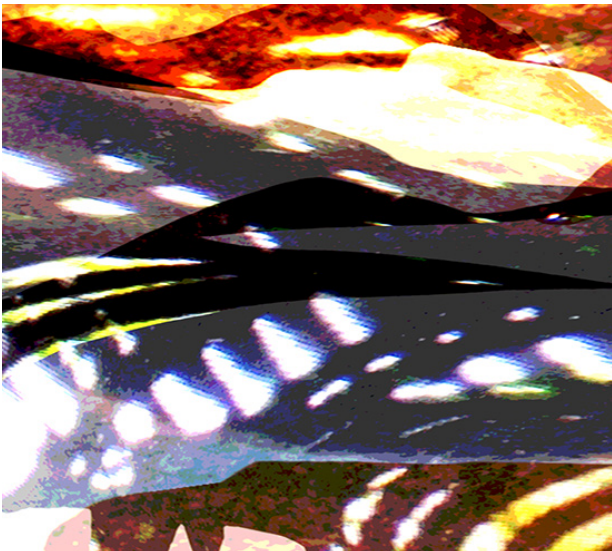


Figure 2 Detail from The Liminal Dress sequence (M Smitheram 2015)

In Figure 2 the remediated image is co-produced by the aesthetics of screen and Photoshop design tools. The original image was manipulated in Photoshop, the computer screen itself was then photographed, and the image entered back into Photoshop creating a generative feedback loop, layering digital pixellation with luminance and reflections from the actual screen surface.

In this case, translation in the artworks is between the digital and physical, activated through the screen. Küchler (2008) interprets this idea of 'screenness' as taking the form of a 'horizontal or spatial network of interlocking artifacts that not only become indistinguishable as they are enveloped by one and the same surface, but may also soon morph into each other' (Küchler 2008: 104).

These examples that have transferred through these different stages of materiality, (physical –digital) carry with them a patina and visual trace of their transference from human hand to program software, from screen to textile, and back again. Figure 3 illustrates the aesthetic qualities of digital glitch. The original photograph of fabric is encoded and the file corrupted through digital processes. The resulting image mediates the physicality of the original image with glitches that are determined digitally. This connects visually with what Thrift (2005) refers to as a new reality in describing this kind of materiality as a new means of imagining the world, a new kind of reality that depends on combining the new senses of 'human' and 'material' that have come to exist.

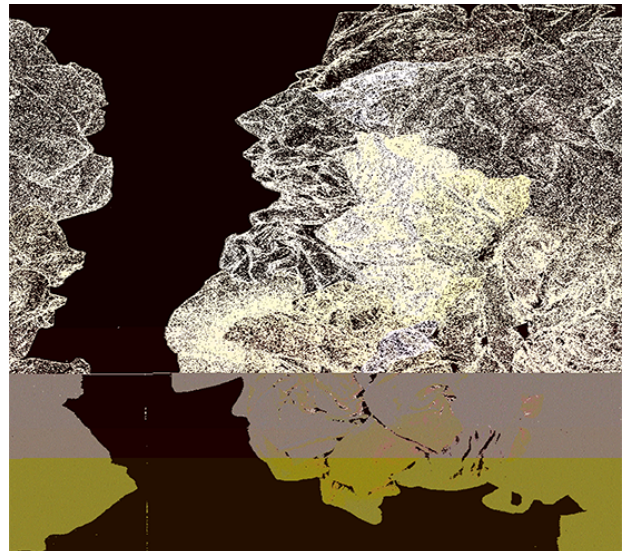


Figure 3 Glitch# 23, (M Smitheram 2015)

In this digital textile practice outcomes are often projected, simulated, or printed, they are not always screen-based in the final output however screen continues to play a part in influencing the aesthetics of the surface. The result is a new hybrid materiality, which is not just one thing or another but a result of a mediation of weaving together the elements of both.

Case Study Two: **Technic and aesthetic in 3D knitted form**

The historic relationship between textile technologies and computing software is widely recognized. Boyd (2013) identifies a number of metaphorical relationships between textile construction and software, generally related to structural or functional similarities. However, the socio-political dimensions of textile technology software, in the way that traditional roles and industrial work practices are echoed in the design of their software is rarely addressed. While software development is often described as a technical process, it is above all a human process where theoretical and cultural backgrounds influence software design (Thrift 2005).

| TEXTILES | COMPUTING |
|------------------------|---|
| Loom | Operating System |
| Fibres, Yarns, Threads | Processor Execution Threads |
| Stitch Patterns | Basic Code Patterns |
| Knots | Loops |
| Textural Patterns | Function Patterns, Template Methods |
| Fabrics, Carpets | Function Results, Global Program States |

Figure 4 The software weaving metaphor (Boyd 2013)

Electronic seamless knitting technology was first introduced in the mid nineties and represented a radical technical innovation; for the first time, textural design, in the form of visual and haptic aesthetics, could be constructed simultaneously with three-dimensional form. However, the arrangement of the technology's user interface and the subsequent design and production system the software advocates is derived from a pre-seamless industrial knitwear culture, essentially masking and limiting the significantly advanced design capability of seamless technology.

Of particular focus in this research project is contesting the technology's prescriptive and conventional two-dimensional garment design format and the continued separation of design and technical roles for knit design and construction. Though these aspects were developed to ease adoption within its intended knitwear manufacture setting, they can be seen to hinder innovative design and application and essentially commit this radical knitted textile technology to conventional garment manufacture (Underwood 2009; Smith 2013).

The proprietary software has two interfaces; one intended for designers and one for technicians. In Figure 5, the image on the left shows the highly abstracted garment interface, with garment silhouettes designed around traditional two-dimensional flat pattern cutting techniques. A designer can follow these silhouettes through a guided process that allows simple adaptations of the front, back and sleeves of a garment to generate a knitting program in the form of a two-dimensional grid. In presenting designers with this abstracted garment interface the software replicates the traditional separation of designer and technician roles in standardised knitwear production.

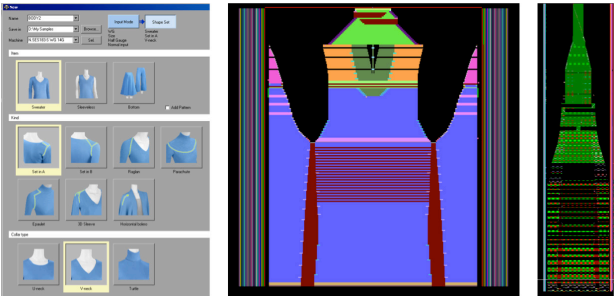


Figure 5 Images from software interface. (J Kalyanji 2015)

For the design and production of knitted form not aligned with garment options, the knit program screen on the right is a starting point. This programming grid is a direct translation of the textile construction space where each column on the grid represents a needle and each row a movement of the knitting carriage. In this grid blocks of colour are encoded symbols, such that each square of colour represents an instruction to be applied to that needle. Working within this programming grid requires a significant level of programming expertise alongside an understanding of the mechanical movements of the machine.

For an expert technician the programming grid is a powerful tool allowing extensive control of texture and shape to be applied to individual stitches. However, as illustrated in Figure 5, there is no graphic translation between the programming grid and the three-dimensional knitted form it represents. That is, there is no visual representation of shape, drape, volume or tactility within the software. This requires the user to engage in an arduous and often ineffective mental translation. Consequently designing three-dimensional form progresses through a cycle of feedback loops between user, machine and knitted form where one can only be sure of what has been programmed by physically knitting the object. Thrift (2005) has recognised this type of exchange between 'human' and 'machine' whereby software acts as a 'mediary' with the power to transform and translate its inputs, embedded in the production of new forms.

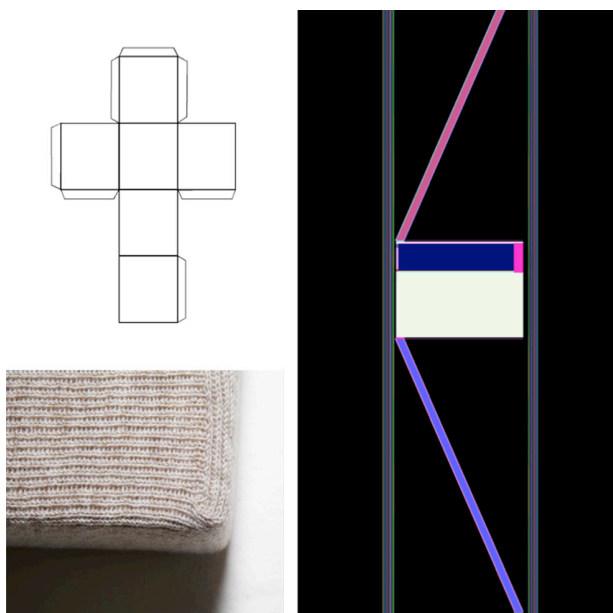


Figure 6 A traditional two-dimensional flat pattern for a box (top left), the knit-programming grid for a seamless knitted box (right) and a seamless knitted box (bottom left).

The Technic and Aesthetic in 3D Knitted Form project continues this type of exchange by reconsidering seamless knit technology as a three-dimensional textile fabrication tool allowing exploration of innovative three-dimensional knitted textile form within a speculative, new dimension. Figure 7 shows an example of such abstract, exploratory three-dimensional form. In dislocating the technology from conventional knitwear manufacture, and learning to use the programming interface, the research also considers the changing balance of design and programming skills that will empower the knitted textile practitioner to engage more innovatively in this emergent field.



Figure 7 Abstract, exploratory three-dimensional knit form. (J Kalyanji 2015)

Case Study Three: **Sapient Materiality: e-Textiles and Embodiment**

The emerging field of electronic or e-textiles is being lauded for its economic potential (Market and Markets 2013; Amed 2016). While there are still many technical problems in bringing e-textile products to the market, the biggest challenge (and innovative potential) they may pose is to notions of human subjectivity through a radical repositioning of bodies, textiles and computing. Twenty-five years ago Donna Haraway first raised questions about relationships between technology, the human body and its boundaries asking 'Why should our bodies end at the skin?' (Haraway 1991:178).

E-textiles are mostly worn on the body in sport, health or safety applications, as sensing and communicating interfaces translating and responding to data from the physical body and/or the environment. Thrift (2005) recognises that notions of the body are being effected by sociotechnical change, where inside and outside are reworked and the world becomes re-animated through ‘all manner of intentional objects’ (Thrift 2005: 246). He suggests that the body forms a new ‘set of informational surfaces which, through the combination of machine and theory, create a new ‘inside’ which is also simultaneously an ‘outside’.’ This repositioning of bodies and technologies challenge notions of the human subject and thus our understanding of being human (Shildrick 2009).

Knitted textiles offer unique opportunities for digital technology integration. Knitting is a multi-layered construction method that can be made as single continuous sheets of fabric (Jost et al. 2014). Weft and warp knitting are engineered structures that can be manipulated to increase functionality. There are three physical scales that affect the dimensional control of knitted e-textiles (Joseph and McMaster 2014) (figure 8).

| Scale | Definition | Dimension |
|-------|---------------------------|----------------------------|
| Macro | Pattern and garment shape | Design or cultural scale |
| Micro | Stitch and yarn structure | Optical microscopic scale |
| Nano | Molecular structures | Electron microscopic scale |

Figure 8 The three physical scales that effect the dimensional control of knitted e-textiles, Joseph and McMaster 2014.

New materials like conductive yarns and nanofibres, and their sensing, communicative and responsive properties are intertwined within knitted stitch structures to affect the mechanical and electronic performance of e-textiles. Dynamic properties such as stretch, tension, texture and shape can be used to enhance conductivity, resistance, signal detection and output to improve electronic performance. Sections, layers or structures made of non-conductive yarn can be used to contain or enhance electrical properties within conductive sections, allowing the development of more reliable and repeatable knitted sensors and more precise placement of sensors.

A number of multidisciplinary, e-textiles research teams and postgraduate students based at the Auckland University of Technology have been investigating the behaviour of knitted e-textile structures and utilising these properties in developing fabric based electronic components and e-textile applications for both artistic expression and for health and well-being. Two projects that utilize some of the specific properties of knitted e-textiles are, the Dynamic Textiles for Dance project (Joseph et al., 2013) shown in Fig 9. below, and the Emotion Sensing Textiles project (Gupta 2014; Gupta, Cleveland and Newall 2014) shown in Figures 10. and 11.

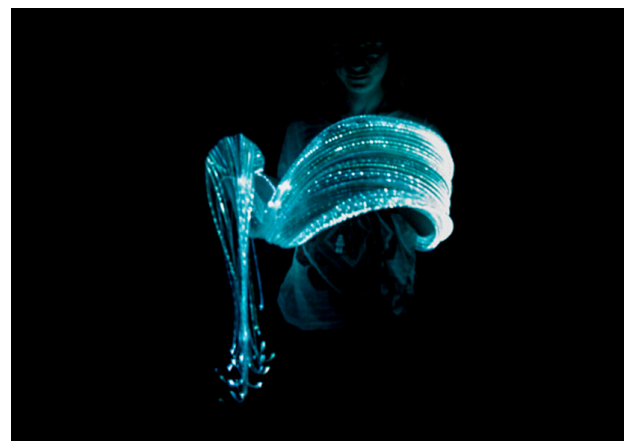


Figure 9. Interactive Sleeve from Dynamic Textiles for Dance Project, (Joseph et al. 2013)

The image in Figure 9. is of an interactive sleeve developed for dance performance. Fibre optics were knitted into a monofilament sleeve and colour change in the textile was programmed to respond to data variations. Changes in sound, the orientation of the dancers body and the dancers respiration rate were all explored as triggers for animation of the sleeve via colour change across the textile (Joseph 2013)



Figure 10. Emotion sensing knitted prototype (Gupta 2014)



Figure 11. Emotion sensing dress (Gupta et al, 2014)

The projects illustrated above involve textiles that can sense and communicate emotional responses through galvanic and temperature change detection. These changes are communicated through colour change using LEDs.

Küchler (2008) has recognized that ‘the materiality of fibre and the structure of fabric is playing an increasing role in (re)animating the material world’ (Küchler 2008:102). In the above examples, textiles are no longer just a protective barrier between the body and the environment. They are materials that can sense and display changes of physical and emotional states, challenging notions of interior and exterior, corporeal integrity and the human subject.

This, we suggest, is a deeper value and more radical potential of e-textiles. Thrift has recognised the biological, human body as being ‘under renovation’ where new materialities are leading to a repositioning of notions of inside and outside, so ‘the body becomes a dynamic map of socio-technical change’ (Thrift 2005: 247).

Miller’s notion of ‘sapient materiality’ where both consciousness and cognition are ‘bound to the specifics of materiality rather than defined by their opposition to a material world’ (Miller 2005: 34) is highly relevant to this inquiry. New sapient materials, like knitted e-textiles, also have philosophical implications in the challenge they pose to dualities of material and immaterial; exterior and interior; body and mind; object and subject.

Part Three: Conclusion

The three case studies presented here, address different areas of textile design and making in relation to technology. While we have emphasized a link between each study to one aspect of Thrift’s tripartite theory of ‘technological infrastructures,’ of screen, software and body, we recognise that the relationships between new surfaces, new frameworks and new sensibilities are important to each project. There is a fluidity and mediation between screen, software, body and textiles in each project, and there is potential to explore each register across the three projects in the future.

Küchler (2008) recognises that clothes and textiles that have been ‘thought to distract from the proper concern with the immaterial, are also, and always have been, the most effective way of inverting the proper relations between animate and inanimate things (Küchler 2008: 115). The intimate relationship between textiles and human beings using traditional craft processes was built on some of the earliest and most significant human technological developments. This longstanding association was ruptured by industrialisation and the development of the mass production of textiles and clothing in the nineteenth and twentieth centuries. In the twenty-first century, digital technologies, as new technological infrastructures are not only changing the methods of textile production but are challenging notions of materiality and human being.

The projects discussed in this paper explore new making processes that not only result in new and original textile designs, but also suggest new technological materialities and associated cultural and methodological shifts. These new approaches are not just about making textiles as material artefacts, but are recognized as 'producing a second skin of new forms of attention' (Thrift 2005: 233), a fluidity that challenges longstanding dualities of material and immaterial; exterior and interior; object and subject. Understanding this deeper and more radical conceptual shift is critical to realizing the full potential of these new technologies and methods of textile making.

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2 - 7 December 2013.

14 - 21 March 2014 and 18 - 22 June 2014.

Established in 2002, the Academy teaches graphic design, photography, illustration and art direction.

21 February - 2 March 2014.

SHIFT was a platform for World Design Capital 2014 within the Stellenbosch region to showcase the innovative capacity and potential for Stellenbosch.

Titled Paperwork: an exhibition of contemporary South African works on paper the show brought together more than 50 works by South African artists utilising paper in different ways across a range of various disciplines and techniques. It included historical works from the mid-1970s up until newly produced works from 2014.

Pass the Camera is a technique developed by American filmmaker Jennifer Fox for her 2006 documentary film Flying: Confessions of a Free Woman in which she instigated dialogue with women in seventeen countries by 'passing the camera'.