

The Living Archive: facilitating textile design research at undergraduate level through collaboration, co-creation and student engagement

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Abstract

With an emphasis on reinventing dress histories through a CAD approach, fashion and textiles archive, The Collections Resource Centre in Leicestershire, United Kingdom, was utilised as the springboard for a visually rich and materially vibrant exploratory investigation. The project married historical artefacts with creative digital technologies in order to redefine fashion/textile objects from the past through practitioner-research. The study focused on textile design research from an Integrated Digital Practice perspective within Higher Education, in relation to learning and teaching at undergraduate level. The archive was employed as a fundamental pedagogical basis to aid research – visual, historical and contextual; observational; hands on experimentation; and design demonstration by investigating archives as pedagogy. The overarching aim was to tease out novel findings by exploring a palette of digital tools, methods, techniques, processes and parameters that may lead to the acquisition of new knowledge, skills and design innovation relevant to academia and industry. This was achieved through a 10-week student bursary scheme at Loughborough University that enabled: institutional and external collaboration between the student-and-staff and the student-and-archive; student-staff co-creation; and by the student engaging with outside organisations, institutions, places, people, events and media relevant to the project. Employing a collaborative and interdisciplinary methodological framework supported the concept of the archive as ‘having life’, based on the initial study, exploration and digital interpretation of selected archival items which resulted in a comprehensive portfolio of artistic ideas, CAD developments, technical enquiry and scientific experimentation. As such, an environment which enabled a dynamic design-research study within a scholarly context was established. The research process was substantiated by the involvement, experience and expertise of academic and technical staff whilst encouraging autonomy from a student perspective. This steered the research and helped to identify potential areas for further work beyond the scope of this project.

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Introduction

Practitioner-research is a relatively new field compared to longer-established academic research disciplines in technical/scientific fields. Elaine Igoe (2013: 5), argued, "...since its inception in the late 1970's, the academic field of design research has lacked significant input from textile design". This suggests some level of underrepresentation of textile design research as a discipline in the wider academic environment. Traditionally, within creative communities, it is common for individuals to create work and engage with creative processes intuitively based on tacit knowledge and skills, often without robust documentation or clear articulation of the ins and outs their practice. Instead, a more organic and serendipitous way of doing things has governed personal actions and outcomes. However in recent years, particularly in the UK, as a result of creative practitioners and educators such as artists, designers and makers doing research, practitioners have engaged with more systematic and methodical ways of experimentation, thinking, documentation and knowledge transfer. Examples include: Goldsworthy (2012); Robertson (2011); Paine (2016); Akiwowo et al. (2014; 2017) and Akiwowo (2015). As such, design-research platforms have emerged as a way of testing ideas, facilitating collaboration and driving the dissemination of practitioner-research activity such as: the Living Research project (2015); Textile Environment Design (TED) research, now the Centre for Circular Design (2017); and the Textile Design Research Group (2018) at Loughborough University, to name a few. Consequently, new applied research terminologies have emerged within this sphere signalling ongoing development within this field, namely: "Practice-led Research"; "Practice-based Research"; "Practitioner-Research"; and "Practice-informed Research".

A shift from design to design-research, as discussed by Laurel (2003: 82), can also be linked to a notable increase in collaborative activity within creative communities (i.e. fashion design, textile design, product design, service design and design crafts) together with "interdisciplinary", "multidisciplinary", "cross-disciplinary" and "transdisciplinary" approaches embedded into the research process. In this manner, the research is underpinned by creative practice and is characterised by making, hands-on exploration and applied methods. This facilitates and encourages imagination, tacit skills and inventiveness or "unspoken originality" – traits that are typically synonymous with forms of artistic expression and interpretation, also acknowledged by Shreeve (1998) and Igoe (2010). Similarly, Paul Chynoweth (2013: 15) argued, "...the process of formal knowledge creation can legitimately draw upon tacit, experientially-generated knowledge from the workplace". Mark Bailey, together with Neil Smith also discussed this type of diverse pedagogical framework in their report for the Design Council on multidisciplinary design education in the UK (Bailey and Smith 2010). Here, they emphasise the value of multidisciplinary working in order to appropriately train and equip design graduates for industry and the requirements of modern society. In a later study about integrated academic practice in design Higher Education (HE), Bailey and Smith (2016: 1) proceed to explain the significance of project-based activity involving external partners in promoting "...high-quality, pedagogically sound, 'authentic' learning whilst offering a research site from which to gather data and in which to validate new knowledge". This seems to suggest that the most effective and relevant type of design education a student can attain, is one that involves some amount of cross-discipline activity and engagement with external bodies such as industry or enterprising organisations. They further argue that this model "...highlights the reciprocal values that benefit Academia, Students and Partners in project-based knowledge, co-creation and sharing" (Bailey and Smith 2016: 1).

In order to further define the position of this practitioner-research and provide greater contextual background for the work carried out, Mick Healey's Research-Teaching Nexus Model (2005) was applied. In this model, Healey and Alan Jenkins (2009: 7) attempt to find links between, and reconcile two distinct and often seemingly disparate elements of academic practice, *Research* and *Teaching*. By focussing on the nature of student research and enquiry from the perspective of curriculum design in HE, the nexus describes two contrasting roles of the student: 1) as participants; and 2) frequently as an audience. These roles are further defined in relation to "research content",

which focuses on acquiring knowledge; and “research processes and problems”, which places emphasis on first-hand experience of doing research. According to the nexus model, as a participant, the student is either, “Research-tutored” and therefore engaging in research or “Research-based” and therefore undertaking research, or possibly both. In contrast, as the audience, the student is “Research-led” which involves learning about current research in the discipline or “Research-oriented” by developing research and inquiry skills and techniques, or both. Therefore, whether students are participants or the audience of research, the model identifies both *Research Content* and *Research Processes and Problems* as factors applicable to both, which is logical. In line with Healey’s perspective, this research holistically considers the role of an undergraduate (UG) researcher by drawing on both participatory and audience-like tendencies and characteristics, as described. In doing so, this enabled the student to engage appropriately with the whole research process.

Unlike a more traditional fragmentation of teaching and research in terms of funding, management and assessment considerations and criteria, as discussed by Locke (2012), the nexus model provides a more rounded framework and starting point in which to analyse and identify pathways leading to the “construction of knowledge”, a notion also explored by Boyer (1990). It does this by supporting the broader concept of the ‘scholarship of teaching and learning’. This standpoint recognises the potential of the student as an active and involved member of the research community within an established academic environment. Likewise, this research facilitated the pedagogical development of textile design research through high-level UG study relevant to further work beyond the scope of the study. The project provided an opportunity for the student to experience research in a positive context, with a view to improving learning, enhancing knowledge, study skills and applied practices beneficial to the personal, academic, creative and professional development of the individual. More broadly, the impact of the study identified advantages for the wider student cohort, development of the programme and academic practices, relevant to both students and staff.

Facilitating textile design research in HE through integrated digital practice

Digital technology as a multifaceted tool within education in developed countries and westernised societies in particular, is unavoidable. Computerised devices and digitised information, methods and systems contribute much of the new skills and ways of learning in this environment. It is therefore unsurprising to perceive much discussion within the sector which tackles a range of issues regarding the role and effect of technology on teaching and learning in a digital age (Beetham and Sharpe 2007; Selwyn 2016; Cambridge International Examinations 2015; Thomas and Morris 2017).

Educators like Melanie Bowles; J. R. Campbell; Helena Britt; and Philip Delamore for example, have spearheaded digital approaches in textile design, fashion design and design education for a number of years (Britt 2008, 2012 and 2013; Bowles and Isaac 2012; Bougourd and Delamore 2007; Campbell and Parsons 2004, 2005; Campbell 2006). Projects and events have explored the role, possibilities and pitfalls of digital technology in art and design disciplines. Through provocation and discussion, topics such as: Digitised design; Dissemination of digital information; Interfaces between science, design and technology; Future craft technologies; Technology driven textile research; Material innovation and pathways to production, to name a few, highlight the significance of digital technology in an age increasingly influenced and governed by expediency, accessibility, originality, possibility and enablement, as examined by: Braddock Clarke and Harris (2012); Nimkulrat et al. (2016); Seymour (2008); Lee (2005); Quinn (2010); Lucy Johnston (2017); and Shillitoe (2013), for instance. Considerations such as creation and design innovation, technological advancement, customisation, sustainability, cloud computing, remote and big data, productivity and economic growth, for example, are pertinent to the 21st century. As such, this presents both new opportunities and challenges

within academia and industry, as well as government to engage in and support teaching, training, research and relevant practices that effectively respond to the present day whilst anticipate future infrastructures, the needs of individuals, society and the planet.

Through a 10-week Summer Vacation Bursary (SVB) scheme funded by the Doctoral College at Loughborough University, second year UG Textiles: Innovation and Design student, Lucy Dennis, undertook this research project between July-September 2017. The work was carried out under the supervision and tutelage of the author, Dr Kerri Akiwowo in the School of the Arts, English and Drama (SAED). The project was co-supervised by Dr George Weaver, Senior Lecturer in Organic Chemistry in the School of Science (SoS) and Dr Guy Bingham, Senior Lecturer in Product and Industrial Design at the Design School (LDS). Further support was provided by academic and technical staff in respective departments. External support was received from Sarah Nicol, Collections Engagement Officer at The Collections Resource Centre (archive) in Barrow upon Soar, Leicestershire, UK. The research involved working collaboratively via an interdisciplinary approach, from a textile design perspective.

The rationale for the project was to facilitate textile design research at UG level, from the perspective of a textile design student specialising in Integrated Digital Practice (IDP). Notably, advances in digital technologies, particularly design which utilises Computer Aided Design (CAD) approaches such as digital textile printing, laser technology, digital embroidery, jacquard weaving, Computer Numerical Control (CNC) knitting and three-dimensional (3D) printing for example, presents an exciting digital tool box for textile designers, engineers and manufacturers to engage with. The project highlights and raises the profile of the newest pathway specialism on the BA (Hons) Textile Design and Innovation programme at Loughborough University. As such, Dennis is one of the first candidates to pioneer the pathway, as of October 2016. Other long-established pathway options include: Print; Weave; and Multi-Media Textiles. The term, IDP within the context of textile design presented here, describes an applied approach to designing that is underpinned by digital technology, digital methods and digital techniques in the process of designing and physical outcomes. In terms of textile design research and development, the presence of applied digital design practices made possible by CAD technology establishes a platform to investigate digital process i.e. machinery, software, operational and design parameters. In doing so, the opportunity to generate and construct new knowledge leading to design innovation and other important insights is an exciting prospect and is relevant to an ever evolving world. To reinforce this point, Professor Paul Rogers (2018) from the Arts and Humanities Research Council recently said, "Design Research in the UK is fantastic... I think we can make it even better".

Reinventing objects from the past

This research pursues the notion of the archive as "having life", by amplifying collected and stored artefacts through the selection, study and interpretation of worn historical clothing objects. The inspiration behind the project considers dress history, object-based research, textile narratives and the preservation, study and interpretation of archival fashion and textiles artefacts. Relevant existing studies include: Lerpiniere (2015); Entwistle (2000); Flügel (1930); Taylor (2002); Haye and Wilson (1999). The visual and tactile characteristics clothes embody such as: shape, colour, pattern, texture and handle in relation to the unseen account of a time past was contemplated; an ideology that adopts the notion of story-telling in order to relive their creation, usage and consumption, as well the behaviours, norms, and rituals they may have created or taken part in, with regards to people. This 'hidden' knowledge is preserved in the physical presence of each object through form and decoration which is visible and tangible, personifying textile designs and material techniques that can be viewed and touched, held or worn. Based on this understanding of; and appreciation for such archival garments, engagement with hand process and practices were significant to the project

underpinned by digital design investigation. This approach made it possible to uphold the aesthetic essence of the past and maintain a tactile and material connection to the historical objects whilst exploring new technological possibilities and material identities through digital experimentation and interpretation. Therefore, drawing, in all its forms played an important role in the work generated. Drawing, as a form of expression, documentation, observation and replication is inherently subjective. Simon Seivewright (2007: 40; 86) describes drawing as a form of investigation, translation and visual language. He proceeds to explain that drawing can often provide greater sensory associations beyond the object alone. In this manner, Dennis, who was the primary viewer of the objects at the archive, engaged in the hand process of drawing as an interpretation outlet. With critical contemporary eyes, she was able to mediate and translate what she saw, linking historical and current values. Similarly, Deirdre Murphy (2011) discussed dialogues between past and present in a previous study about historic garments as source material for contemporary fashion design. She argued, '...research, which enables dialogues between historic and contemporary fashion, helps to build new, more complex narratives about both past and present.

The practical design aspects of this research were underpinned by selected archival garments chosen from different eras (Figure 1). This selection mostly reflected the author's personal preferences whilst incorporating visual and decorative differences between items. The purpose of this approach was to maintain and encourage variety throughout the research process regarding the source materials observed, digital processes explored and anticipated design outcomes. The artefacts were provisionally pre-selected by Akiwowo in conversation with Nicol, then later edited by Dennis and finally jointly confirmed by both Akiwowo and Dennis. This collaborative decision making process initiated the start of a "co-working" environment relevant to the wider research project and subsequent archive engagement between: Dennis and Akiwowo; Dennis and Nicol; and Akiwowo and Nicol. In order to build links between the archival garment and the technological process, an instinctive decision to marry specific historical garments with particular creative digital technologies was made. In doing so, the project explored opportunities to reinvent objects of dress from the past through contemporary digital textile design practices. From an available palette of five potential processes including: digital embroidery, digital printing, jacquard weaving, 3D printing, and laser processing, four approaches, excluding laser methods, were taken forward for further study. This decision was made based on the set length of the project and existing laser processing knowledge acquired pertaining to Akiwowo's previous research (Akiwowo 2015). Scientific investigation into functional digitally printed textile surfaces explored the potential for advanced opportunities regarding IDP within a textile design context. By working in this way, it was possible to synthesise historical objects with research insights through creative digital technologies and systematic investigation. This unique symbiotic relationship between old and new characterised the archival/pedagogic core of the study.

Through a practitioner-researcher approach, the study encompassed first-hand investigation, collaboration, co-creation and student engagement with multiple practices on an interdisciplinary level. This methodological framework involved student/staff and student/archive interactions alongside ongoing involvement with outside organisations, educational institutions, historical and contemporary places, people, related media and relevant academic events. Through this process, a comprehensive portfolio of design work and scientific inquiry leading to an experimental body of digital and scientific outputs was generated. It is anticipated that the results of this exploratory investigation will provide the basis for further work. It is also expected that outcomes of this preliminary study will be disseminated as appropriate such as: publications, impact case study material and exhibitions.

Research question, aims and objectives of this study

The overarching research question underpinning the investigation asked:

How can historical objects of dress inform new digital pathways to textile design through integrated digital practice?

Aims and objectives of this study

The aims and objectives of the study outlined in Table 1 are presented and discussed in relation to project expectations and anticipated achievements. Aims: 1, 2 and 3 are linked to Objectives: A, B and C.

Methodology: utilising archives and collections as pedagogy in textile design research through a collaborative and interdisciplinary approach

The pedagogical framework undertaken in this study supports the underlying goal of the work to enable an appropriate student-focused research environment for textile design students studying at HE level. The methods identified and carried out by Dennis primarily support and favour the practitioner-research standpoint of the enquiry, which also embeds other discipline specific approaches relevant to the investigation. The overarching approach for undertaking the study employs collaboration and interdisciplinary working in order to support a co-working environment suited to operating across more than one discipline. This was achieved via a mixed method approach. Therefore, both qualitative and quantitative methods and perspectives were embedded into the research process. This methodological structure (Figure 2) facilitated learning, the acquisition of research insights and pathways to generating new knowledge. Several qualitative approaches undertaken allowed the process of “data gathering” to encompass: individual thought and expression; human connection; process and meaning; value and quality; experiential involvement with activities and practices; first-hand interactions; descriptive analysis; and visual materials. The quantitative aspects of the study involved: systematic experimental data collection; quantifiable explanation of results; statistical analysis; measurable variability; graphical or statistical representation of results; computational models; and repeatable techniques.

Five key research methods underpin the research process:

1. Utilising archives and collections as pedagogy;
2. Student engagement: activity specific participation and investigation;
3. Data collection: experimentation, categorisation and thematic documentation;
4. Evaluation: ongoing reflection and post-project analysis; and
5. Demonstration of creative ideas and design results (further discussed in the concluding section).

In terms of hands on practice and first-hand interactions, seven main areas of enquiry define the developmental stages of the work regarding an applied approach, as detailed in Figure 3.

Collaboration as a way of nurturing interdisciplinarity in textile design

Collaboration aids the linking of different knowledge types; ways of thinking and doing; diverse perspectives, varying expertise, and sometimes contrasting disciplines. In recent years, interdisciplinary research, collaboration and discussion around these approaches in design research has become increasingly more prevalent within textile design, demonstrated by studies such as: Briggs-Goode et al. (2016); Bye (2010); Akiwowo (2015); Igoe (2010); Marr and Hoyes (2016); and Veja (2015), for example. Valentine et al. (2017: S9965) argue that "...textile design is distinct and interdisciplinary in nature". In this manner, practitioner-researchers collaborate with other creative practitioners or those in entirely different fields who possess unique discipline specific skills and know-how or whom may be affiliated with key networks and organisations that will steer and benefit the research. The *Intersections* Conference held at Loughborough University in London on 13-14 September, 2017, organised by the Textile Design Research Group, focused on collaborations in textile design research and to some extent demonstrated this perspective through academic papers and exhibition disseminations.

The value of problem solving through collaboration can be attributed to a holistic, all-inclusive approach which may lead to innovation based on the diversity and richness embedded into the research process achieved through a joint effort (Papnek 1984; Dorst 2006). Working in this way can be advantageous rather than adopting a single discipline approach which may be limiting. It can also be argued that the attached value of collaborative and interdisciplinary working in textile design research inevitably brings about greater impact regarding the research results and rigorous approach adopted due to the scope and reach of the work. This consideration is particularly important in academia, where impact is recognised and measured through the Research Excellence Framework (REF) system for assessing the quality of research in UK HE institutions (REF 2018).

Through a collaborative and interdisciplinary approach, this research embeds three main disciplines including: Textile Design, Design Technology and Chemistry. In doing so, Dennis adopted a "T-Shaped" framework for carrying out the study. This model, thought to originate by McKinsey and Company, was discussed by the Bailey and Smith (2010). Similarly, Seidel et al. (2007) discussed the role of interdisciplinary working within the academic curriculum in relation to manufacturing and product innovation by offering insights from an innovative educational programme standpoint. By positioning textile design as the core subject within the project, aligned to Akiwowo's primary area of expertise and Dennis' current educational training, a deep knowledge of the subject can be understood. This represents the vertical single-discipline bar of the "T" considered to be an "I" approach that is narrow, tight and highly specialised. The horizontal "T-bar" represents the breadth of study by facilitating the production of different knowledge types and creating a richer learning experience for Dennis. Therefore as a practitioner, Dennis, for the first time was able to shift and grow her focus to encompass a broader investigation incorporating less familiar disciplines. This subsequently benefitted the development of the project in terms of identifying potential areas for innovation as well as gaps in knowledge from a textile design perspective. This methodological approach was in line with the aims and objectives of the work and was necessary to achieve the thematic project goals and anticipated outcomes.

Co-creation: a product of collaboration

Collaborative activity typically harnesses the sharing of ideas, knowledges and skills, further contextualised by Cross (1999). It is therefore inevitable that this "meeting-of-minds" breeds an environment for some amount of crossover, parallel and similarity. Transversely, this may also apply to the opposite whereby two or more entities fit or come together because of difference, complimenting one another in some way, which is just as valuable. As such, a platform for co-creation may be initiated – the production of something such as an idea, process or object, for example, involving two or more bodies such as people or organisations. Regarding textile design and textile design research, this may involve co-designing or co-working leading to particular outcomes, as explored by Valentine et al. (2017); Malins et al. (2012); and Fairburn et al. (2016) as well as

product design and development consultancy, *Thread* (est. 2016), for example. As such, collaboration and co-creation may be considered interchangeable in some working environments. This thinking is appropriate to aspects of the research described through this article.

The methodological framework employed enabled Dennis to co-create with Akiwowo through regular informal dialogue, formal scheduled weekly meetings and through day-to-day developmental discussion about the creative and applied aspects of the work in relation to other areas of the research. In this capacity, ideas were exchanged and confirmed by both parties through an effective collaborative synergy; also with Weaver as needed, through one-to-one meetings about planning and carrying out hands-on lab experiments, and during supervised experimentation. This enabled meaningful interaction, further discussion, the development and documentation of knowledge based on real-time scientific findings. Similarly, meetings with Bingham through one-to-one conversation, ongoing work in progress dialogue and 3D software tutorials enabled Dennis to develop sufficient preliminary knowledge and skill to first sketch 3D geometries independently by hand and confirm the work with Bingham. Based on his expertise and knowledge of the 3D printing process, Bingham later made necessary digital adjustments to Dennis' initial artwork, during the CAD modelling stage. Ongoing co-creation was therefore considered an integral part of the research process in this study.

Archives and collections as pedagogy

At the Collections Resource Centre (CRC) archive, Dennis was able to view and touch the garments first-hand in conversation with Nicol. This interaction functioned like a bespoke seminar by providing greater contextual background about the items documented by notetaking. Further historical and contextual data linked to the garments was gathered independently to onsite archive research. With the ability to handle and visually document the artefacts, as the primary viewer, Dennis contextualised the garments further through her own interpretations involving internal thoughts, photography and observational drawings. Dennis visited this archive on more than one occasion. Upon her first visit she remarked: "I was overwhelmed by the amount of [visual] information at first so, I had to go away and process everything, then return after digesting it all having given things some thought". To support this method of learning and process of interpretation, the investigation was supported by an independent visit by Dennis to the Clothworkers' Centre for the study and conservation of fashion and textiles at the Victoria and Albert Museum (V&A), London, UK. Dennis viewed, documented and interpreted the pre-selected garments, made by Akiwowo, according to a template specifically devised for this task (Figure 4). Therefore, structured archival object studies were undertaken. The template comprised an A4 document whereby the catalogue and descriptive details per piece including: Item; Catalogue Number, Year, Designer/Producer, Fabrics/Materials and Production method needed to be entered; other sections included space to note: Use of colour and Key features. The template also identified space for two digital photos of the garment (one of the whole garment; the other of a close up detail); and finally a section for Initial Observations. This template was accompanied by a quick drawing or series of sketches for each garment, as determined by Dennis and so outcomes were unique to her (Figure 5). The purpose of working to this structure was to facilitate effective time-management and bring about a sense of uniformity within the controlled environment and short study period. This approach encompassed visual, empirical and interpretive visual data in line with a qualitative approach that enabled individual thought and expression, as explained by Smith and Dean (2009: 4).

Student engagement: activity specific participation and investigation

The student learning experience was enhanced further by creating opportunities for engagement internally and externally. Internally, Dennis' participation involved meeting with a subject librarian at the university library early on in the research. The purpose of this approach was to discuss the project one-to-one, in relation to the specialised physical and electronic resources available to support the work and enhance the investigation by using subject specific journals and databases that

Dennis may not usually use or be aware of in her daily UG studies. Interdisciplinary collaboration and first-hand interaction with multiple disciplines enabled Dennis to carry out work across three schools – SAED, Design School and School of Science. This involved the use of workshops, hubs and labs; and liaison with technical and academic staff in both a practical and informative capacity, such as through CAD tutorials or meetings, for example. According to Dennis (2017), when asked whether she felt the balance between independent study and project supervision/staff contact worked well, Dennis (2017) replied, “Yes, Kerri and I met at least once a week to discuss the project, the schedule and how to further progress parts. Meetings with the other staff also worked well to support the progression of this project. By undertaking different aspects of the project at different times across the 10 weeks, it was possible to focus with particular staff at different points in the research”.

Dennis’ external engagement can be likened to activities typically undertaken by a first year practice based doctoral researcher in an art and design discipline in terms of connecting with outside organisations, institutions and resources. In this manner, Dennis embarked on archive visits, attended exhibitions, was introduced to specific media recordings, became a conference delegate; and attended a talk at The Fashion and Textile Museum, London by Lydia Edwards (2017), author of *How to Read a Dress: a guide to changing fashion from the 16th to the 20th century*. Dennis’ personal involvement and accumulated experiences provided a rich and varied introduction into how textile design research may be supported and developed by leaning on primary and secondary sources such as those described and by participating in relevant events and practices. Similarly, Philip Martin (2008: 300-322) describes education in the arts and humanities as “...not primarily structured around the imparting of skills and competences, but one primarily structured around a series of engagements with a body of knowledge or (in the case of the practical arts) a body of practice”.

Data collection: experimentation, categorisation and thematic documentation

Data collection or data gathering carried out in this research involved the acquisition and collation of multiple data types. The term “data” was broadly considered in order to fully encompass both qualitative and quantitative aspects of the investigation. This included visual information such as the study of objects and images as well as technical and scientific experimentation involving computational or numerical process and analysis. Textual documentation was employed as way of capturing operational data relating to specific practices through written meeting notes. This method also enabled the gathering of internalised human data by using a reflective journal to record project progress in relation to first-hand experience and personal development. Regarding the creative aspects of the research, four main design concepts were identified in response to the initial selected archival artefacts; in relation to specific digital technologies, processes, exploration; and in line with Dennis’ and Akiwowo’s previous work (Table 2).

This thematic approach initiated a system for contextualising the production of knowledge and physical work. Adopting this method made it possible to categorise and critically reflect on all areas of the investigation in relation to a logical framework relevant to wider considerations beyond the scope of this study. Additionally, working in this way also made it possible to identify gaps in knowledge or skill in relation to opportunities for further work.

Evaluation: ongoing reflection and post-project analysis

The process of evaluation carried out in this study supported project progression and Dennis’ educational experience as a researcher. Evaluative approaches facilitated learning and supervisory input through critical reflection and the appraisal of ongoing work generated. Informal day-to-day dialogue between Dennis and Akiwowo maintained an informative understanding of developments, both significant and incremental. As such, this regular contact created a platform for ‘comfortable communication’ and helped to foster a sense of trust between both parties. Scheduled project meetings (weekly: Akiwowo/Dennis; weeks 1, 3, 7, 10: Project Team) functioned in a similar way allowing lines of communication to be opened up further amongst members of the project team.

These meetings provided an opportunity to view and discuss progress made, steer further developments and allow Dennis to effectively connect with academic staff, in person. An ongoing reflective journal aided self-assessment (Figure 6) by making daily entries into a structured one-page digital template whereby Dennis was able to identify the: Day; Week; Date; Main Task(s); an Image of the day; and Reflections in response to four simple questions aimed at stimulating critical thinking – “What do I know today that I didn’t know yesterday? How does what I did today relate to work planned for tomorrow? What went well today – why? What didn’t go well today – why?”

Upon completion of the research, a report was produced by Dennis in order to synthesise the work carried out and disseminate the results to the wider academic community at Loughborough University. This writing process aided further evaluation through formal composition and interpretation of outcomes in the form of text and images. A student self-assessment questionnaire, designed by Akiwowo, was completed by Dennis after the study. This provided an opportunity to reflect on and evaluate the project overall, from a student perspective. Equally, the responses to the survey capture Dennis’ experience as a research participant and gives greater insight to the impact of the study on her personal and professional development. In particular, she remarked, *“This project couldn’t have been more relevant to my chosen specialism. It was better than expected as it has become so valuable in terms of my learning/understanding as well as research developments. I have also learnt more about myself doing this project and how I work best which has been very beneficial and therefore made me more productive. I think this will have helped me for my final year quite significantly...”*

Experimental parameters

This section sets out the experimental parameters used in this research. Thematic documentation facilitated a methodical experimental approach. As such, the experimental parameters employed are identified in relation to the main areas of progress and the project themes (Table 3).

Experimental results and discussion

The experimental results presented and discussed here focus on the practical outcomes of the research. This work comprises physical elements generated by exploring digital design process inspired by historical archival garments. The experimental results are discussed according to each of the four themes identified:

Trompe l'oeil Translations: Jacquard Weaving

A jacquard weaving process was chosen for exploring Trompe l'oeil three-dimensional illusions in response to three archival garments (Figure 7). This selection inspired the development of form during the experimentation and designing stage. As such, draping, fringing, tonal variation, stripes, florals, folds, pleats, frayed edges, gathers and ruffles were considered with regards to creating 3D effects on a piece of 2D cloth. Creating the visual appearance of folds/pleats through a surface design approach was chosen and investigated further.

Prior to utilisation of the ScotWeave jacquard software, designs were generated in Adobe Photoshop. Designing comprised two main elements – generating a floral/striped repeat design made from curved panels to replicate folds; and developing a halftone gradient pattern to work as a background in order create depth and tonal variation (Figure 8). Within the gradient, where darker tones or shadows were specified, this represented the inside of a fold. Lighter tones behaved like highlights and represented the top/curve of a fold. A series of experiments with pixel size variants was necessary to achieve appropriate definition on the resulting digitally woven fabric. Equally, the decorative repeat pattern was adjusted by rescaling the design to allow more curves across the fabric as to increase the illusion, in relation to the gradient background pattern. Having made these modifications, the two files were layered and coloured as appropriate, in preparation for further specification in ScotWeave.

In order to translate the CAD files onto fabric via Eltex DataWeave jacquard machine, ScotWeave facilitated the specification of weave structures concerning weft yarns and the warp. The design file contained a monochrome aspect (background gradient) and the decorative curved folds were coloured in alternating panels of pink and blue to distinguish both the top and inner areas of the design (Figure 9). The pink panels denoted a weft facing weave in a bright yellow polyester yarn. Blue panels denoted a balanced weave structure in a more 'washed out' appearance of the yellow yarn due to the equal presence of off-white warp yarns. The background gradient pattern was woven using a contrasting weft facing burgundy cotton yarn. This experimentation produced the desired effect which was to create a trompe l'oeil 3D simulation on a flat textile surface (Figure 10). The eventual result presented and discussed here was achieved through exploring and understanding a range of CAD parameters regarding both design aspects and statistical variants.

Areas for further work include:

- **Precision with colour:** Explore a colour palette that would allow for a more original and unexpected demonstration of colour use across the digitally woven fabric by considering spectral tonal variation in relation to Chroma and hue colour characteristics.
- **Gradient development:** A gradient approach presents a number of possibilities to graduate different levels of tone within a textile structure and across the surface. Such effects may also be further enhanced by applying specified gradients to individual motifs within a design leading to more complex and innovative digital design outcomes.
- **Reversible fabrics:** Sometimes the reverse of many experimental samples were as, if not more intriguing as the face of the fabric. Therefore, the possibility of developing technical

double-faced cloth was realised, which may be relevant to apparel markets, interiors, the built environment or medical and functional textiles contexts, for example.

Transformative Prints: Digital Printing with Scientific Experimentation

The Transformative Prints theme enabled the advancement of a well-established CAD process and consideration of an advanced IDP approach by integrating scientific enquiry into functional textile surfaces via hydrophobicity experiments. Relevant existing scientific studies include: Vasiljević et al. (2013); Dornyi et al. (2008); Lei and Lewis (1991); Mahltig et al. (2010); and Abbas et al. (2017). This investigation considered the potential to embed additional properties into digitally printed apparel, particularly for outerwear apparel such as jackets and other water-resistant garments within a fashionable contemporary design, sportswear and athleisure context. As such, patterning; juxtaposition; bold colour; and functional aesthetics were considered in terms of design direction. Four archival garments (Figure 11) informed the initial development of repeat patterns leading to small scale and coordinate designs. Patterns were created by simplifying and modifying shapes found in the original historical garments then reducing and repeating the scale of these elements (Figure 12).

In a lab setting using a structured experimental approach, chemicals Octanoyl Chloride (99%) and Perfluorooctanoyl Chloride (97%) were applied to cotton twill cellulose fabrics in order to test the possibility of adding hydrophobic properties to the textile such as water or oil resistance. Using plain and digitally printed specimens, fabric samples were soaked in each chemical for specific lengths of time to assess hydrophobicity based on different levels of absorption. Once removed from the solution and naturally air-dried, specimens were tested by using a pipette to release droplets of water or oil on to the treated fabric to observe the formulation of a bead and/or the rate of dispersion across the surface fibres (Figure 13).

Here, I will present and discuss an experiment carried out with Octanoyl Chloride to observe the effect of water on treated and untreated, washed and unwashed cotton twill fabric. Each specimen measured 5.5cm² and weighed 0.004mol prior to treatment. 3.9g of Octanoyl Chloride was combined with 3.1g of an organic base compound, Di-isopropyl ethylamine. This combined solution also contained Ethyl acetate to facilitate some dilution of the substances. Six washed specimens and six unwashed specimens (three plain and three printed in each set) were submerged in the chemical solution inside cylindrical tubes. Once submerged, a timer was activated in order to record the removal of samples from the solution. Two specimens (plain/printed) from each set were removed after 10 minutes, two after 2 hours and two after one week. Each pair of specimens was washed twice in Ethyl acetate, then in Methanol and again in Ethyl acetate. The results of the experiment are documented in Table 4. The results show that the washed printed cotton sample repelled water marginally more than the plain washed specimen. Overall, washing had a significant effect causing the reduction of Octanoyl Chloride and therefore the property of the chemical to decline. As such, a difference of approximately six hours before dispersion in unwashed specimens, compared to 1-2 seconds for washed specimens was recorded. However, in washed samples, although chemicals absorbed a lot quicker than the unwashed specimens, the rate of dispersion was slower avoiding flooding the fabric.

Areas for further work include:

- **The effect on coloration:** An ability to effectively achieve hydrophobic properties with digitally printed textiles as explored may be to the detriment of the design in terms of surface appearance, wash fastness of pigments or dyes and the effect of pre/after washing. Such considerations are relevant to industry in terms of textile coloration and textile finishing processes, commercial standards and the manufacture of textile goods. The potential to chemically impregnate or coat individual yarns/fibres and textiles prior to or

simultaneously during the digitally printing stage with pigments/dyes via ink-jetting technology is an exciting prospect and may provide more scope to embed design and functionality within a single textile structure at the pre-production or production stages.

- **Weave structures and substrates:** Exploring a range of weave structures may produce different results. For example, some weaves are made up of closely spaced, tightly woven weft/warp yarns producing a more rigid structure. This in turn may cause a slower or reduced chemical reaction in terms dispersion and absorption of the hydrophobic solution within the fibres. Equally, experimentation with a range of substrates such as other cellulose fibres, protein fibres, regenerated fibres, synthetic materials and mixed fibre content fabrics will broaden the scope for investigation and therefore a diverse range of outcomes expected.
- **Experimental practices and parameters:** Weighing fabric specimens before and after treatment would provide an assessment based on weight change to indicate whether molecules have successfully bonded to the fabric in relation to any alterations to material properties likely, if so; specimens could be washed using different detergents and with varied water temperatures or via dry cleaning processes; droplet formulation may be analysed further by measuring the contact angle of beads formed on the fabric; and tests carried out with different chemicals on digitally printed samples may indicate alterations in colour attributed to specific compounds, which is useful, particularly from a design and coloration perspective. Different pigments or dye shades may produce different effects depending on the chemical or solution and/or the composition of a dye.

Next 3D: 3D Printing

Next 3D was mainly inspired by the Next archive which has been housed at the CRC archive since 1982. The theme was developed around three garments (Figure 14) together with an earlier line of clothing by the high street chain store, “Next Too” (circa 1988). The design concept considered: geometry; configuration; tessellation; and surface in relation to potential digital processes including: 3D printing; dye sublimation printing/heat transfer; laser dyeing; and laser etching. Therefore, both the constructed and surface decoration aspects were contemplated. As such, some investigation into both 3D printing and printed design was achieved, demonstrated by a limited body of 2D and 3D experimental preliminary work.

A goal was set to make a link structure in order to create a piece of textile based on an introduction to Solidworks 3D printing software, under the tutelage of Bingham. The resulting textile surface would potentially be “decorated” using a heat sublimation transfer printing method. Therefore, a collection of themed print designs was also generated (Figure 15). In Solidworks, it was necessary to select a “plane” or area to work in incorporating 0.4mm gap so that the links have room to tessellate. By adding “fillets”, edges became curved and smoothed off so that individual links were not sharp and rigid, likened to a conventional soft textile structure. To create a piece of textile from a link, a linear pattern must be inserted and a direction for the repeat chosen. Dennis first produced a series of hand sketches and technical drawings (Figure 16) in order to understand how the links may be realised in CAD as well as exploring how the design of a link would be suitable for printing a pattern onto the surface area. The sketches developed into three-dimensional paper maquettes (Figure 16).

This hands-on exploration provided an informative first-hand learning experience for Dennis and a valuable platform for knowledge transfer directly beneficial to her and for the acquisition of new knowledge relevant to the wider student cohort, the IDP pathway and the development of textile design as a discipline generally.

Areas for further work include:

- **3D printed structures and surface design development:** It would be both a rewarding and insightful development to progress initial sketches and paper maquettes into actual 3D printed samples. In doing so, it will be possible to assess the physical artefacts by employing a textile design perspective to evaluate structure, drape, handle, appearance and possible application, for example. The potential to carry out comparative studies with specific conventional textile structures in terms of material properties and characteristics is also an interesting prospect. Equally, the production of 3D printed samples would facilitate exploration into surface design and coloration with printed or laser based digital approaches. This enquiry also considers the potential to simultaneously print and colour/pattern a 3D printed structure in situ, relevant to existing and future developments in technology within this field. Such advancement would bring 3D printing into closer alignment with other textile printing technologies from both a design and manufacturing perspective.

Monochromatic Grandeur: Digital Embroidery

The Monochromatic Grandeur theme explored decadence through contrasting “black” and “white”, “white on white” and “black on black” using a digital embroidery approach. Therefore, a restricted palette of white/off-whites, black/greys was employed with a focus on exquisite interpretations, decorative details and luxury regarding motifs and patterns. This enquiry supported Dennis’ existing knowledge and experience with the technology in relation to previous work (Cotton USA 2017). The starting point for experimental investigation was underpinned by five archival garments that embody hand process, human labour, dexterous skill and high-level creativity (Figure 17). A range of fabrics were sourced for sampling by acquiring textile remnants and using off-cuts from second-hand clothes. Unique motifs were created based on initial observational drawings and drawing/design developments (Figure 18), later calibrated via CAD for stitching out designs onto fabric. Selected results, corresponding parameters and observations are set out in Table 5.

The results of this exploration demonstrate digitally embroidered interpretations of historical hand embellished garments. Design outcomes were achieved by rigorous technical understanding of mechanical parameters in relation to design and material considerations. Dennis’ familiarity with the technology (Wilcom software/Brother machine) facilitated an adept ability and informed confidence during the process. This experience also enabled troubleshooting and decision-making regarding a large range of CAD parameters in order to initiate an inspired range of decorative effects. It is acknowledged that the visual outcomes of this work sit closely in parallel with the original archival garments. The two groups of artefacts, both historical and contemporary, although distinctly different in their fabrication, are aesthetically comparable in execution despite a difference of more than a century regarding their creation. This relationship to some extent brings an amount of synthesis between both low and high technologies, past and present, old and new.

Areas for further work include:

- **Design innovation:** The ability to technically determine and modify specific effects through automation via CAD process means the platform for harnessing design innovation is vast. This knowledge and understanding combined with human creativity and tacit intuition of the individual sets a precedent for the utilisation and demonstration of the technology within design and manufacture sectors such as: textiles; apparel; furniture; and product, for example. In this manner, further opportunities for customisation and on demand processing may also be realised through further investigation and development of processes and technologies in this field.

Conclusion and further work

The research presented and discussed in this paper was underpinned by the utilisation of archives and collections as pedagogy within a HE environment to facilitate textile design research at undergraduate level through collaboration, co-creation and student engagement. The notion of a “Living Archive” was employed. Access to a local archive (CRC) was both invaluable and fundamental to the study. Previous engagement with Nicol and prior first-hand knowledge of the types of items held at the archive was both advantageous and rewarding for both Akiwowo and Dennis. This positively impacted the project in terms of accessibility, communication and contact.

The research enquiry supported the development of novel ideas, outcomes and experimentation with digital tools, together with scientific investigation. The depth and value of creativity within the project leaned on the inventive and imaginative background of Akiwowo, Dennis and Bingham, as design practitioners. Each party contributing different levels and types of disciplinary expertise, knowledge and skills in order to benefit and enhance the project in both anticipated and unexpected ways. From this collective portfolio of practitioner experience, innate capability and tacit skills, a rich platform for cultivating design innovation and original knowledge was established. Scientific enquiry into functional textile surfaces regarding the digital printing aspects of the work explored the potential for advanced IDP within a textile design context, beyond the conventional parameters of a creative discipline. The key practice based research results are attributed to: Jacquard Weaving; Digital Printing with Scientific Experimentation; 3D Printing; and Digital Embroidery. Other key results comprise human centred and tangible outcomes directly related to Dennis by supporting her as a designer, researcher and final year student. In summary, Dennis described her experience as “Valuable”, “Positive” and “Enriching”. Notably, the potential for larger student cohorts to be impacted is evident also. With some adjustment to teaching and learning approaches, tasks and activities, this could be achieved. In particular, collaboration and interdisciplinary working, as well as the introduction of selected study tools designed in this project such as object study templates and the reflective journal could be adapted to enrich the student learning experience in different educational scenarios.

Some challenges and limitations were also acknowledged. Halfway into the project, it was clear that the 3D printing aspects required more investment of time; skills based learning and knowledge transfer compared to the other areas of investigation. Had this been perceived prior to commencement, an alternative schedule of work and/or a different set of goals regarding this aspect may have potentially allowed for greater targeted progress and fulfilment.

Fundamentally, this study promotes a Research-Informed Teaching approach within design HE and demonstrates direct impact on the student learning experience. By focusing on “students as participants” within a research context, the study is a pedagogic exemplar that demonstrates support for UG students in developing their research-related knowledge and skills.

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