Assemble: The Artifact as a Collaborative Tool in Knit Design Research

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ABSTRACT

This paper presents a new perspective on the role of the artifact in knit design research. The artifact is presented as a stimulus for interdisciplinary research where practice based enquiry provides only part of the required methodological approach. Reporting on a major collaboration between the curator of the Oriental Collection at The Royal Armories, Leeds, and researchers from the School of Design at The University of Leeds, this paper pursues two key trajectories. Firstly, the paper outlines how the artifact can be used as a design stimulus for interdisciplinary collaboration. This is assessed across multiple stages of design and through the production of several perspectives on key thematic ideas. Secondly, the paper reports on how collaboration, specifically in the development of these alternative perspectives, can lead to materials innovation. These two points of discussion are contextualized with reference to interior architectural installation, Inflection, and supported by analysis of The Knitting Machine, Cocoon and knitted exterior installation Configure. Findings highlight how the use of artifacts enables practitioners to adapt thinking using material practice in order to generate new knowledge.

KEYWORDS: knit assembly, architectural interior installation, the artifact asa collaborativeresearchtool, archives, materialperformance

Introduction

In knit design research, practice based enquiry enables designers to innovate with materials and technologies to produce knitted textile solutions for an increasingly broad range of spatial applications. Collaboration between disciplines provides a mechanism to achieve a step change in understanding and designers are increasingly working alongside engineers and scientists in specific project teams (Quinn 2013; Yelavich and Adams 2014; Nimkulrat, Kane and Walton 2016). At an architectural scale, knit research often requires collaboration between architects and textile designers. For example Architect Jenny Sabin worked with textile designer Anne Emlein on the myThread Pavilion (Sabin 2013), and Listener (2011) is the outcome of interdisciplinary collaboration between architect Mette Ramsgaard Thomsen and Textile Designer Ayelet Karmon. Writing about this work Thomsen and Karmon identify the opportunity afforded through this knit collaboration as a means to reconsider materials specification in the development of active and performing architectures (Ramsgaard Thomsen and Karmon 2011). While the textile designer’s technical knowledge of materials and technologies is necessary for production, collaboration at the design stage enables interdisciplinary exploration of site and materiality. This paper reports on interdisciplinary collaborative research between knit design researchers Jane Scott and Elizabeth Gaston, and Natasha Bennett, the curator of the Oriental Collection at The Royal

Armouries, Leeds. The aim of the research was to reimagine the Chinese armor collection in order to engage new audiences with the pieces on display. The outcome was a new architectural interior installation Inflection designed for one of the most iconic sites in the museum and exhibited in Spring 2017 (Figure 1). Working across the disciplines of textile design and historic archives provided a unique perspective on collaboration. Artifacts from The Royal Armories collections were critical to define and develop the parameters of the research. A key objective for the team was to identify suitable historic textile armor, and to analyze the materials and construction processes that lead to performance characteristics of these artifacts. The methodology used for the research explores the use of the artifact as a means of communicating thinking across disciplines between textile design and historians (Scott and Gaston 2017). The ability to innovate with material practice was particularly evident when the functionality of specific artifacts were discussed across disciplines. Throughout the research process an emerging vocabulary was developed that could relate to both historic arms and armor and contemporary CNC knitting technologies.

The Artifact as A Tool for Collaborative Textile Design Research

The artifact is recognized as a key tool used by designers to develop knowledge and understanding during the research process (Cross 2001). In this research, the term artifact is used to describe historic objects from the museum collection, knitted textile samples and prototypes created during the research, and Inflection, the architectural interior installation exhibited in the Hall of Steel, at the Royal Armories, Leeds. It is significant that three different types of artifact are evaluated at different points within the research process. In addition, through the collaborative process, artifacts are introduced and assessed from distinct perspectives; that of the designer and historian. This complexity is addressed in the methodology developed by Cross who outlines three research activities where the artifact becomes fundamental to the research process: the process of designing (1), reflecting on the knowledge embodied within an artifact itself (2), the knowledge that results from making, and reflecting on the process of making the artifact (3) (ibid). The role of reflection within practice-based research (Sch€on 1983) continues to find agency within contemporary textile design research (Nimkulrat 2012) and specific examples of collaborative research highlight the importance of reflection for the development of new approaches and new outcomes (see Thomsen and Tamke 2009; Marr and Hoyes 2016).

Figure 1 Inflection, The Hall of Steel, The Royal Armories, Leeds. Copyright: Scott and Gaston (2017).

Reflection on the role and application of the artifact as a tool for design research has been further contextualized with the emerging field of materials-led design. From a materials perspective, the methodology outlined in research by Thomsen and Tamke (2009), describes how the artifact can be understood as materials evidence against which project aims and objectives can be assessed (Thomsen and Tamke 2009). Thomsen and Tamkes's approach is particularly useful here as it presents three specific contexts in which material evidence can be applied into materials-led practice:

- The design probe: a design-led investigation allowing speculative inquiry, theorization and the setting out of design criteria.
- The material prototype: a materially-led investigation allowing exploratory testing, of craft and material behavior. The prototype answers and develops the design criteria of the design probe.
- The demonstrator: an application-led investigation allowing interfacing with real world problems and constraints (Thomsen and Tamke, 2009:3).

Clearly, the organization of these three modes of investigation is structured to support design development and realization of a project at different stages. In the research detailed within this paper, the terms probe, prototype, and demonstrator are particularly useful to articulate both what and when artifacts fit into wider project development.

The Design Probe

To initiate the research collaboration between Bennett, Scott, and Gaston, a selection of artifacts from the Oriental collection were analyzed by the knit design researchers. Artifacts were selected during a tour of the museum stores and a general introduction to the collection.

Artifact 1: Lamellar Armor

Within the Oriental Collection at The Royal Armories there are significant pieces of Chinese lamellar armor. Chinese lamellar armor often presents as constructed textile armor composed of leather plates laced together with thick leather thongs and assembled into armor plating using a complex pattern of interlacing (Figure 2). Lamellar armor was in widespread use across Asia for centuries, affording the wearer flexibility in situations where maneuverability was as important as robust protection (Bennett 2017).

What is immediately apparent is how the interaction of two textile materials; the leather plates and the leather thong, using a lacing process generates a three-dimensional form with exceptional strength and toughness suitable for armor. In particular, the form of both.

Figure 2 Lamellar Armor with interlaced plates. Copyright: Board of Trustees of The Royal Armories [permission granted by the copyright holder].

individual plates, and the overall geometry of the armor is created by the positioning of the lacing within the structure. The series of individual plates and lacing structure determine the basic geometries of the lamellar armor. However, on analysis of the armor, it is evident how the original geometries are adapted through use. Both the temporal and the personal act on the underlying geometry to produce unique three-dimensional forms. This was particularly evident on analysis of a helmet, one of the key pieces within the collection. This threedimensional form had clearly been sculpted over time by the individual who had worn the helmet. This was noticeable around the neck where the plates were warped, curving in against each other through use and through the aging of the natural materials over time.

Artifact 2: Composite Bows

A second series of artifacts which informed design research were the collection of Chinese composite bows (Figures 3 and 4). These bows are constructed from a combinations of horn, wood, and sinew. Textile in the form of sinew is tensioned by the belly of the bow, which is made from horn and wood which are recurved so that they bend in opposing directions when relaxed or tensioned. The horn is critical to provide flexibility to the belly of the bow as it is “springy under compression” (Selby 2000). In contrast, the sinew is used to

Figure 3 Composite Bow unstrung. Copyright: Board of Trustees of The Royal Armories [permission granted by the copyright holder].

Figure 4 Composite bow strung. After bow is strung the bow is recurved in the opposite direction. Copyright: Board of Trustees of The Royal Armories [permission granted by the copyright holder].

form the back to the bow because it resists stretching, finally the core is constructed from wood. This combination of materials gives the bow its speed and force.

> The stave, horn, and sinew work together to give the optimal balance of draw-weight and lightness in hand. It is difficult to argue that the three materials can be divided into which gives speed, which gives distance, and which gives penetration. But combined, these three materials yield this combination of qualities (Selby 2000: 99 –100).

Here, Selby explains how the bow provides an excellent example of a composite material, where the properties of several materials work together to provide optimum functionality. Recurved describes the process of tensioning the bow. In its relaxed state the bow curves in one direction. When strung the bow is recurved in the alternative direction (Richardson and Bennett 2015). This material system provides a carefully engineered assembly with the material properties of each component engineered to provide the required tension and compression once the bow is recurved, and strung ready for use.

Through analysis of lamellar armor (LA) and composite bows (CB) from the perspective of both the artifact and the material probe, three construction principles emerged. These principles provided the underlying motivation for decisions at both the prototyping and demonstrator stages of the research.

1. Construction composed of a series of individual shaped pieces (LA).

2. Composite material system engineered to generate a tensioned form (CB).

3. Localized shapes of individual pieces inform the overall shape and form (LA) (Scott and Gaston 2017).

These initial design probes validate the importance of Cross’s concept of reflecting on knowledge embodied within an artifact (2001) as a tool for collaborative research. Selection and analysis of artifacts allowed collaborators to gain significant insight into design and construction. In addition to the collaborative selection process, the interests of each individual team member and the common interests of the whole team emerged.

The use of artifacts as design probes presented an opportunity to define material properties and construction processes suitable for the design development stage. This initial brainstorming activity at the beginning of the research, referred to as “fuzzy” because of the lack of a complete understanding in which direction the work would develop (Sanders and Stappers 2008) was punctuated by reference to these specific artifacts. This enabled the functionality of historic artifacts to be analyzed against the knit designer’s knowledge of materials and textile process, leading to transferable principles that could be explored through material prototypes.

The Material Prototype

While it is evident how the lacing structure in lamellar armor could be used to inspire textile design it was critical to adapt this process to knit. In a knitted structure, the mechanical strength and flexibility and are generated using a loop construction process to form a continuous material rather than an assembled material. Therefore, the contrast between the construction processes can be identified as the difference between mechanical properties achieved from the assembled construction (lamellar armor), and mechanical properties integrated into structure of the materials (knit). The temporal quality of how the materials behave over time, and in response to use was another factor that was considered in the design; how could the installation be formed and reformed to express the temporal dimension?

The Knitted Installation

In order to produce a large scale knit installation based on the three construction principles outlined above, analysis of a series of recent installations developed by Scott and Gaston was undertaken. Three particular installations were presented to Bennett (using swatches, demonstrations, and photographs) as alternative design solutions for the production of knitted fabric within a spatial context; The Knitting Machine (Figure 5) (Scott 2017), Cocoon (Figure 6), and Configure (Figure 7). Each architectural piece applied the materials, technologies, and techniques of knitting in a different way; offering alternative perspectives on knit as an artifact. The Knitting Machine, composed of lengths of tubular knit monofilament and lurex was constructed as a performance piece in the Parkinson Building, Leeds. For this work, the material properties of the knitted monofilament were critical to how the site was defined. While the construction was tensioned at the top, the bottom of the installation was free to move. Despite its size, The Knitting Machine embodied such lightness that the internal air circulation was materialized as it billowed within the open space below. In contrast, Cocoon, composed of dense ropes of wool roving and non-woven fabric formed a snug, enclosed knitted space. Knitted by hand using large scale loop construction processes the

Figure 5 The Knitting Machine, Parkinson Court, Leeds 2016. Copyright Scott and Gaston (2016).

Figure 6 Cocoon, 2016. Copyright Scott and Gaston (2016).

Figure 7 Configure, environmentally responsive assembly, fragment at building scale, Clothworkers South Leeds, 2016. Copyright: Scott (2016).

work was suspended from the mezzanine to retain a unique threedimensional form. For Cocoon, interaction with the site was principally observed through public engagement with the work. It was possible to sit, or lie in the knitted form and the public occupied the soft space as a site of reflection and relaxation.

The third knitted installation, Configure, is an environmentally responsive knitted assembly designed to engage with the changeable weather of a Yorkshire Summer (Figure 7). This piece was exhibited as a fragment at building scale on the outside of Clothworkers South in 2016. Configure was produced using an assembly system first developed for environmentally responsive shape-changing knitted assemblies The Species (Scott 2013). The scale of the work and the exterior location demanded alternative materials; polypropylene replaced natural fibers and the wood veneer increased in thickness from 0.2 to 2mm. Despite the change in scale of the material components, the complexity of the fabric was retained. The piece was programed to knit as a branching structure with multiple, integrated segments using Shima Seiki CNC knit technologies.

These three installations offer distinct visions for knit as an architectural material; in each approach, the material qualities are key to understand firstly how the installation interacts with the site, and secondly, how the public engage with each textile space. The soft interior of Cocoon is contrasted with the rigid veneer inserts necessary for Configure to produce responsive three dimensional forms. While the ephemeral qualities of the oversized loops that make up The Knitting Machine move with only changes to air circulation in a building, Configure requires rain to actuate the assembled materials. In terms of interaction, for Cocoon this is with the public as a shared or solitary space for inhabitation. In each example knit is both inside and outside, seen and unseen, ephemeral and solid. Despite this, each piece shares the knit architecture of repeating courses and wales, and the challenge of producing and maintaining three-dimensional form is overcome at different points of the textile hierarchy; through the material, the process, or the assembly.

Prototyping the Assembly

The process of textile sampling that underpins the textile design research process can be characterized within Thomsen and Tamke's framework as the material prototype. At this stage, exploration of material properties, techniques, and construction processes are explored and adapted through multiple iterations. During the interdisciplinary research process undertaken in the development of Inflection, this is the stage that was most challenging for the team. The expert role was reversed from the curator to the designers and the concept expressed through material swatches samples and drawings. During this process terminology developed to articulate the key criteria of the historic artifact was repurposed to describe the knitted artifacts. As the work progressed a fragment of the proposed installation piece was knitted at full scale to demonstrate both the esthetics and the performance of the knitted assembly system.

The Demonstrator: Reassembling the Artifact

The research application was to design an architectural installation to engage new audiences with the collections at The Royal Armories. At this stage, the location was critical to the final development of the material system. The outcome was the design of an architectural installation in a public location, presenting the opportunity to test the assembly system at full scale in The Hall of Steel at The Royal Armories.

The Hall of Steel is an iconic location; characterized by repeating columns of arms and armor displayed in the central staircase of the building. As one of the major visitor attractions in the museum, the team considered carefully how an installation could be designed to enhance rather than disturb the esthetics of the site. Here, excellent precedents exist; for example Shane Waltner's Chihuly Doily #1 (2004), enclosed the Chihuly chandelier in the central lobby of the Victoria and Albert Museum in London with an installation constructed from tensioned crochet lace. This intervention encouraged the public to explore the space from a new perspective, using the textile to produce a "deliberate disruption of the site" (McFadden 2008: 92). Similarly, the design of Studio Manferdini's Inverted Crystal Chandelier at Birmingham Museum and Art Gallery (2011) sought to capture the lightness and drape of a textile at architectural scale without compromising the site or the materials: "this installation explores the power of ephemeral surfaces to suggest space without confining its edges" (Manferdini 2011: 68).

Capturing the Unseen

While the composition of the original artifacts from the Oriental Collection, lamellar armor and the composite bows exploit the exceptional properties of natural materials, restrictions placed on the project demanded that the installation was composed of synthetic materials. Synthetic materials were selected that captured qualities first explored in The Knitting Machine, a combination of nylon monofilament and lurex achieving light, transparent qualities; a shadow of knitting physically projected against the rows and columns of armor in The Hall of Steel. Into this translucent fabric lasercut panels of 2mm clear Perspex were inserted. In many ways material selected appeared contradictory to the material properties of the original artifacts, however the intention was to unify the performance characteristics of the material system derived from lamellar armor and composite bows, with the location for the installation within The Hall of Steel. By selecting transparent materials the installation could provide both a new artifact within the space, but also a new means to engage with the historic objects on display, and to reconsider the scale and impact of the location itself.

Collaboration for Materials Innovation

One challenge when working across disciplines was how to develop a common language that could be used to analyze both historic artifacts and textile samples. It quickly became apparent that performance and materiality were shared terms of reference and the hyperspecification of materials was identified as critical for armor, arms, structured textile design, and knit programing. This terminology provided a foundation for the design and development of the knit installation.

Analysis of Inflection

The design of Inflection was informed by all of the construction principles identified through analysis of the historic artifacts (LA and CB) at the material probe stage. The combination of knit and lasercut Perspex created a series of individual shaped pieces (LA). Each insert produced a different 3D form depending on its shape, and on its position within the installation. Although each tubular section produced a unique tensioned form (LA), the five sections overlapped each other at the top and bottom, recurving the overall piece in a new direction. Recurving is a key term in reference to composite bows because it describes the process of changing the direction of curve under tension. Inflection produced a recurved form using a composite material system, engineered to generate a tensioned form on installation because of the knit/Perspex construction (CB). This technique of recurving the assembly provided a means to physically represent the temporal qualities (how the helmet had changed in shape over time) observed in analysis of the lamellar armor (Scott and Gaston 2017). The assembly was formed during the multiple stages of construction; initial during manufacture as structural properties were combined to produce the fabric panels. The second stage was the insertion of lasercut Perspex to provide each insert with 3D form. Next the assembly was reformed by assembly from five individual lengths into one large piece, and finally when the piece was hung the final geometries could be observed (Figures 8 and 9).

The Artifact as A Tool for Collaborative Knit Design Research

At each stage of the research project the artifact was critical in developing collaborative thinking. This artifact was either located within the museum collection (composite bow and lamellar armor) from previous installation work (The Knitting machine, Cocoon and Configure), or developed during the design process (knit samples and prototypes). In each instance the use of a physical entity to focus discussions was a key tool within the collaborative research process. In this research, the use of textile sampling and prototyping extends beyond the object itself and instead becomes a process of making, and explaining the ideas implicit within a prototype, identified

Figure 8 Inflection, detail of individual lasercut inserts in fabric. Copyright: Scott and Gaston (2017).

in codesign methodologies as “making, telling, and enacting” (Sanders and Stappers 2014: 7). Using prototypes to articulate thinking and materialize the design concept provided a valuable tool and acted as a means of communication across the disciplines of textile design and historic archives. In this experience, the textile artifact was a central concern of both areas of work. From a design perspective, it was particularly important to consider the perspective of the curator who confronted each knit prototype as she would an historic artifact, analyzing the materials and construction process incorporated within the fabrics. From the design perspective, the construction processes that allowed artifacts produce and retain their 3D forms were of particular interest, one key activity through the work was to find opportunities to develop this approach to form finding in knitting.

One technique that is regularly incorporated into both co-design and collaborative research is workshops. This offers the opportunity to explore materials and techniques suitable for knitting leading to greater understanding of the potential of the material system. Sabin highlights workshop situations as key activities within the programs

Figure 9 Inflection echoes repeating forms within the Hall of Steel. Copyright: Scott and Gaston (2017).

of research (Sabin 2013). As part of the public program of activities surrounding the launch of Infection, a workshop was developed where the public could test the materials using simple freehand loop construction processes. While this offered insight into the chosen materials after the development of the work was completed, it is significant that activity did not take place at the project inception stage. A practical workshop could have extended the knowledge and experience of Bennett during the course of the project and would have extended the co-design methodology further. Public feedback from the workshop was very positive and the workshop outcome was a co-designed canopy displayed alongside Inflection. This textile form, made by the public replicated the materials selected for Inflection.

In terms of materials, the historic artifacts were composed of 100% natural materials, precisely specified to provide the functionality demanded by the arms and armors. Due to museum regulations it was necessary to interpret the design of Inflection in synthetic materials. However, the mechanical properties of flexibility, tension, and compression remained critical to the selection of both constituent materials (monofilament, lurex, and 2mm Perspex) and the construction processes, (weft knitted fabric and lasercut inserts). In addition the use of transparent materials enabled the team to unify the multiple artifacts and interact with the space as Inflection provided a new lens through which to observe the site.

Table 1 assesses the importance of the artifact in this collaboration between designers and historians. Here, each artifact has been mapped against the activities; making, telling, and enacting. While the historic artifacts provide excellent tools for collaborative analysis and interpretation (telling and enacting) the textile samples and production of Inflection further enhance the role of the artifact through the process of making (making, telling, and enacting). The making

Table1 Table mapping "making, telling, and enacting" against artifacts for collaborative research process.

stage is critical to the creative process, it is at this stage that the concept for Inflection was developed from analysis of the historic objects. This supports the design research process outlined by Cross (2001) who identifies the unique knowledge that results from making and reflecting on making an artifact. Enacting is also a critical process for this collaborative research.

For this research, the enacting stage evaluates the behavioral properties of each composite system. In the lamellar armor, the composite system comprises individual leather plates which are formed initially by patterns of interlacing and subsequently by their use as armor on the body. In contrast, the composite bow integrates materials into the structure of the bow and the behaving function is the speed and power generated by recurving the bow for use. Inflection presents a combination of these techniques; knitted sections are individually assembled into unique 3D forms, however an alternative profile is generated when the installation is constructed by overlapping the sections. Enacting therefore becomes a particularly useful term for analysis of these transformable and behaving material systems.

The significant difference between the interpretation in the role of the artifact presented by Cross and Sanders & Stampers resides in the agency embodied within the artifact itself. For Cross, the artifact has a key role in enabling designers to discuss, develop, and reflect on ideas. However, by incorporating the "enacting" process within a codesign strategy, the artifact itself is presented with the opportunity to generate new knowledge. This is achieved through engaging multiple perspectives within a physical object. In interdisciplinary and collaborative research, this provides a significant opportunity to advance thinking both within disciplines and across disciplinary boundaries. The application of this method within the textile design research reported in this paper is significant. Here, the individual historic artifacts of lamellar armor and composite bows are used to inform the performance functionality of a very different material practice in textiles. While the technique of the assembly had been explored in previous work by Scott, the scale and ambition of Inflection presented different challenges in both materials and manufacture. It was through the resolution of these technical difficulties that the enacting artifact presented an opportunity for innovation. Material performance translated across scales and construction processes.

Conclusions

On exhibition, the interior installation piece, Inflection spanned 6m across The Hall of Steel, suspended on tension wires and producing a novel curved profile reminiscent of the lamellar armor which inspired its construction. The installation was very well received and remained on exhibition for three months, however the significance of the research extended beyond the artifact itself. Rather the importance of the research is in the articulation of a practice-based, collaborative, and interdisciplinary methodology utilizing artifacts as probes, prototypes, and demonstrators to materialize research findings. In addition, it is significant how the development of a common language of materials and performance evolved through collaboration between textile designers and the curator of the Oriental collection. The use of the artifact to inform this language was critical; particularly through the evaluation of the material properties of textile samples and prototypes, in relation to the historic artifacts selected from the Oriental Collection.

The key findings of this research paper relate to the successful implementation of the research methodology from the perspective of collaborative research in knitted textile design. While the critical analysis of prototypes and samples are fundamental tool in textile design research, it is worth noting how well this process translates to interdisciplinary research across specialist domains of knowledge. The artifact became a central part of the collaborative process, and an opportunity to share knowledge from both the perspective of the museum collections, and the specific interest in knitted fabric design. It was important that all contributors were able to bring new artifacts for discussion, and that the research process was not limited to a specific materials or techniques. It is acknowledged that this could have presented a problem when the aim was to construct the outcome using CNC knit technologies. In this research, the concept of enacting is developed as a means to explore material behavior, and this offers insight into how the methodology can be applied further to the design of new classes of active and behaving textiles.

From the perspective of materials-led collaborative research, the tools of probe, prototype, and demonstrator are essential to drive innovation within the discipline. What is demonstrated in this research is how textiles can intervene in the public awareness and understanding of a range of disciplines, bridging contemporary concerns of the material and the production processes with historic ideas of performance and functionality. Inflection, through the application of high tech manufacture and engineered synthetic materials, produces a contemporary response to natural, handmade arms and armor, sculpted by time and use.

Knit has a unique set of material behaviors and characteristics, and there is limited research expressing these qualities at an architectural scale. From a methodological perspective the significance of this paper is the model of collaborative, interdisciplinary practice driven at each stage by the physical intervention of the artifact. The success of this methodology is demonstrated through the outcome; materials innovation for knitting at an architectural scale using the assembly system. Working across disciplines with designers and curators has enabled the development of advanced material understanding based on historic construction principles.

In addition, this paper highlights the potential for knowledge transfer from a historic context to contemporary textile technologies through analysis of the artifact. In light of the new manufacturing capabilities afforded by CNC knit technologies, extensive further research should be undertaken revisiting the advanced understanding of materials and performance evident in historic arms and armor. Composite bows and lamellar armor provided a combination of performance characteristics that enabled the production of an original materials system for knitting at an architectural scale.

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