The idea for ‘All Makers Now?’ emerged from research undertaken by the digital crafters in the Autonomatic research group at Falmouth University.

The conference agenda proposed and critiqued a new vision for craft where makers everywhere can harness the power of digital technologies to create, co-create, collaborate, make and sell. Using a FabLab or Makerspace anyone can be a craftpreneur, can’t they? Coming at this digital crafting capability is a bigger cultural agenda: how do we make more fluid and meaningful connections between our networked digital and physical worlds? What do we need to make digital things well, to make them fun, make them work, to delight, challenge, entertain or educate? What role does craft have to play in rethinking the limited physical characteristics of smart devices?

The conference brought together creative professionals and academic researchers investigating craft in new contexts and its potential to contribute to contemporary social, environmental and cultural challenges. Broadly speaking the conference covered three main themes:

• **Materiality and Aesthetics**: creating extra-ordinary and otherwise unobtainable digitally designed and made objects
• **Enhancing the Object**: making out of the ordinary digitally networked things that facilitate new forms of user engagement and participation
• **Democratising Technology**: widening access to digital tools and support for designing and making things using the internet and digital manufacturing technologies

This document is divided into these three broad thematic areas with a brief introduction to each theme.

The conference presentations, workshops, demonstrations and digitally crafted objects explored the value of making within these themes and demonstrated the ways in which craft expertise continues to be tested and redefined for contemporary society. A visual record of the event can be found on the conference website.

**Theme 1: Materiality & Aesthetics**

*Lost in Translation?*

Craft practitioners have long established and well recognised expertise in the inter-relationships of material, technology and aesthetics, i.e. in making meaningful and beautiful physical objects through the skilled use of tools.

This conference theme explored the impact of the new industrial revolution on the aesthetics and materiality of 21st century production and specifically the role that craft values have to play in digital cultures. The papers in this section were invited to describe, explore and critique the following:

• Opportunities arising for developing new aesthetic qualities through the use of digital tools.
• The significance of materiality, physicality and aesthetics in digital production.
• Opportunities for craft practitioners to contribute to developing technologies and/or to make their own digital tools.
• The role of craft practitioners in interdisciplinary teams and collaborative research projects.
• The opportunities and limitations for meaningful interactions and new forms of aesthetic through combining web-based interaction and digital production.
• The capabilities of code and generative systems to enable material aesthetic output.
• The value of craft skills and material understanding in developing human computer interfaces and understanding human relationships with physical objects.
• The poetics and craftsmanship of object making in the realm of pervasive media and the Internet of Things.

**Theme 2: Enhancing the Object**

*Bells and whistles?*

Interactive digital technologies provide unique opportunities to enhance material objects and create new forms of interpretation and user engagement in a range of contexts including heritage, healthcare, wellbeing and sustainability.

This conference theme explored the integration of networked digital technologies and associated online content in the design and making of interactive
objects and interfaces that facilitate user engagement, participation and collaboration. The papers in this section were invited to describe, explore and critique the following:

- Opportunities for crafted objects and installations that extend participation and interaction, and develop new value through digital means.
- The evaluation of audience participation and conduct developed by and through digitally networked objects.
- The impact of digitally enhancing artefacts on the audiences’ direct experience and relationship with the object as the primary focus of their attention.
- Examples of interdisciplinary collaborative practices that have enabled successful outcomes.
- The opportunities arising from increasingly affordable and accessible technologies that provide low cost, flexible solutions for users, curators, artists, designers and crafts practitioners.
- Audiences creating their own interpretive responses, constructing stories and reconfiguring content.

Theme 3: Democratising Technology

All Makers Now?
The world of making is changing. A loose collection of individuals, groups and communities including hackers, tinkerers, fabbers, and crafters, are emerging as something that can be identified as the ‘Maker Movement’, reflecting an increasing number of people’s desire to be defined through being creatively productive. Electronics and embroidery, ceramics and computing, printing and programming have become unexpected bedfellows.

Increasingly accessible and affordable digital technologies are central to a resurgence in making, opening up new opportunities for people to design, make, share, test, learn and sell in a global community. Fab Labs, Makerspaces and Hackerspaces and other types of open workshops bring different approaches to providing access and support in using a flexible and powerful digital toolset. Through this open provision of production, capabilities, that until recently were only accessible through industry or university research units, the Maker Movement claim to be lowering barriers and side-stepping gatekeepers, enabling people to ‘make almost anything’.

This theme raised questions about the activities, aspirations and claims of the Maker Movement and the wider community of innovators and practitioners, with particular emphasis on the role of digital production and digital media technologies in empowering people.

Contributors in this section were invited to describe, explore and critique activities and issues within this area including:

- Challenges to traditional modes of production and consumption.
- Tensions between autonomy and/or individual self-reliance and opportunities for collaboration and co-production.
- The potential for digital tools and resources to enable business innovation and enterprise through individual or group engagement.
- Projects that explore how maker communities can connect with and benefit individuals and groups with explicit needs.
- Historical parallels and economic perspectives on current developments, e.g. the DIY movement, pre-industrial workshops and the Arts and Crafts movement.
- Theoretical perspectives, e.g. flexible specialisation, prosuming and disruptive technologies.
- The relationship between new making spaces and communities, and established craft guilds, studios and groups.
- Sustainable business models for community production labs and their users.

Autonomatic
Autonomatic are an award winning group of design researchers with experience in ceramics, metals, glass and textiles. As creative researchers they have a keen interest in inventing new ways of making things for contemporary contexts, asking ‘what if?’; ‘so what?’ and ‘what next?’ They apply an open and exploratory approach to using digital technologies, integrating them with traditional materials, tools and methods to achieve innovation in process and product.

Established in 2003, Autonomatic work locally, nationally and internationally on live projects, disseminating research through conferences, publications, exhibitions, practical demonstrations and fora. Cornwall provides the backdrop for their research. As a region of beauty, relative isolation and a history of artistic endeavour, it presents great challenges and opportunities for exploiting the potential of digital production tools and the connectivity of the internet.

To see an archive of their work go to: www.autonomatic.org.uk/archive

Katie Bunnell

Makernow
Developed out of Autonomatic research activities, Makernow is an open digital fabrication workshop (Fab Lab/Makerspace) based at Falmouth University’s Penryn Campus.

As a resource of people and digital equipment, Makernow aims to inspire and facilitate individuals, communities and businesses interested in using digital tools. It provides a creative and open environment to learn, make and share. Marrying the research expertise of Autonomatic with the skills of digital technologists, Makernow provides excellent creative and technical support for designing, making and researching using
digital tools, electronics and programming. Its aim is to ‘craft the digital’: bringing craft sensibilities together with digital technologies to create new interactions and experiences for contemporary contexts. The first digital fabrication workshop to open in the South West of England in September 2013, Makernow has already undertaken many projects both small and large. Find out more here: www.makernow.org

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**Betagrams: Maker culture and the aesthetics of prototyping**

Gabriella Arrigoni, Tom Schofield, Teresa Almeida, David Chatting, Ben Freeth, Annika Haas, and Diego Trujillo-Pisanty

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**Abstract**

Maker culture and the convergence of digital technologies with DIY approaches to fabrication are imbricated with a transformation of art practice, particularly regarding works produced in media labs, research institutions or hackathons. These works tend to be released in the public realm in non-stable versions, sometimes only partially working or assembled with easily available materials that do not conform to polished exhibition standards. Additionally, they often carry an expectation for others to contribute to further development, adaptation or customisation, whereas the priority for their creators is in the process and outcomes of a series of iterations and experimentations. Against this background and in order to understand a portion of current artistic production, the notion of the prototype as an aesthetic paradigm is suggested. The underlying implication is that provisionality, open-endedness, collaborative implementation, and future orientation are features belonging to the work not just as a phase in the making process, but also after its encounter with the public. A study was carried out in the form of a curatorial project displaying artworks developed in the same research lab and that together constitute a non-exhaustive taxonomy of the features of prototyping. The works embrace an aesthetic of making and crafts not only by adopting cardboard, textiles, and found elements but also an explicitly visible infrastructure as main materials. These materials and the processes they are associated with resonate with notions of manual skills, touch and intuitive manipulation. Additionally, they play with another interpretation of the prototype; that of an object for testing a hypothesis. This paper highlights the integration of the tangible practice of making and the research of each individual artist. The result is an entanglement between three elements: an historical shift in practices of making, a particular aesthetic approach and the conceptual paradigm of prototyping.

**Keywords:** Prototyping, curating, practice-based research, aesthetics, materiality.

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**Introduction**

The notion of prototype has recently gained currency among scholars because of its implications in a number of disciplines and contexts, including open source software development, digital fabrication, speculative design, open innovation, *maker* and recycling movements. More specifically, prototypes are becoming relevant not just as a step of development in product manufacturing, but as something endowed with intrinsic value both as an artistic medium and a research process. With the spread of practice based research and research through design, and environments devoted to knowledge sharing and collaborative making such as media/fab/hack labs, it is argued that a novel kind of prototypical creative artefact is coming to the foreground. These works tend to be released in the public realm in non-stable versions, sometimes only partially working or assembled with cheap materials without any particular effort to achieve polished exhibition standards. They often carry the expectations for others to contribute to further development, adaptation or customisation, whereas the priority for their creators is in the process and the outcomes of a series of iterations and experimentations.

This paper describes an exhibition curated by the author Arrigoni, *Betagrams* (2014), bringing together works by six artists/researchers. Although the displayed artefacts are not all explicitly defined as prototypes, they challenge this concept, help to define its boundaries, and ultimately epitomize a number of features of prototypicality, as it will be outlined in the following paragraphs. A curatorial process has been adopted as a research methodology to generate a tangible manifestation of the aesthetic of prototyping, but also to collect information by creating dialogue opportunities with the artists and the public.

The structure of the paper includes: an overview of the cultural context where prototypes are becoming relevant; a description of each individual piece, to highlight their specific prototypical features; a discussion around the relationships between making, empiricism and research; and some final remarks on the influences of maker culture on the aesthetics of prototyping.

**Prototyping Cultures**

The new relevance that prototyping is acquiring in artistic and curatorial practice is rooted in what has been described as ‘prototyping cultures’ (Calvillo et al.)
THEME: DEMOCRATISING TECHNOLOGY

2010), to describe the interrelated co-existence of a set of otherwise heterogeneous factors. These can be grouped into the four porous clusters of participation, remake, process and speculation.

Besides a notion of participation, by now endemic in contemporary art (Bishop, 2012), it is instructive to point out how prototypes can be seen as a platform for the involvement of different contributors in a design process, as in participatory design (Schuler & Namioka, 1993). Participation in relation to prototyping takes a number of forms and aspects. While creativity has come to be considered as a form of sociality in itself (Leach, 2012), the notions of open innovation (Chesbrough, 2003), and lead-user (Von Hippel, 1986) suggest how collaboration and openness have transcended the realm of cultural engagement to manifest themselves as corporate principles. The collaborative dimension of prototyping is particularly conspicuous within the open source movement, where the release of unstable (or beta) versions of software is regularly cited as a case in point to highlight the relevance of large-scale user feedback in implementing new products (besides direct contributions to the code). The potential for personalisation supported by digital fabrication technologies can be seen as another form of co-creation where every end-user intervenes and accomplishes an existing prototype. Finally, wider publics can take part in innovative projects just by supporting them on crowd-sourcing platforms such as Kickstarter. Prototypes are launched in the public realm in the form of proposals, and a range of rewards are offered to crowd-funders should the project achieve the necessary resources.

Remaking practices include various forms of remix, re-purposing, hacking, re-cycling or up-cycling, often associated with a DIY and grassroots ethos. This suggests the idea that products are intrinsically unstable and entitled to complex life-cycles and are constantly subject to transformation. The concept of process was central to different historical movements and tendencies in contemporary art, ranging from Minimalism to Conceptual and Performance Art. More recently, the spread of maker culture introduced a novel instantiation of the term. It is, however, the way process has gained prominence in the articulation of public cultural events that is central to understand the role of the prototype in curatorial practice. A whole range of formats that tended to make processes and making activities public enriched the curators’ possibilities alongside traditional exhibitions displaying finished, static artefacts. Workshops, labs, hackathons, dorkbot meetings, maker fairs, demo sessions, presentations of work in progress, field trips, residencies and seminars either directly involve the public in the making or turn the making into a (semi)public event in its own right.

The fourth tendency is associated with the notion of speculation. Speculative and critical design projects are most commonly presented to the public as prototypes of possible future products, to encourage the viewer to reflect upon the relationship between value systems and technological innovation. Prototypes intended as an outcome in themselves, rather than a step towards mass manufacture, are also regularly generated within research through design and practice-based research, as tangible instantiations of hypothesis or testing environments to explore and evaluate ideas.

**Betagrams: An overview**

As anticipated in the introduction, each of the works in Betagrams is proposed as an expression of a particular aspect of prototypicality, and the curatorial process contributed to the draft of a not exhaustive taxonomy of the features of prototypical artworks. These can be described as objects for improvisation, testing, fictionality, research, iteration, critique, customisation, re-making or recycling, as it will be illustrated more specifically for each of the works.

**Corrugations** by David Chatting (2014a) (2014b), is part of a series of cardboard prototypes reframing a discarded mobile phone and, by re-proposing the old as cutting-edge, questioning the notion itself of innovation. The device, hidden inside a spherical (re)packaging, activates a hidden segmented fan which opens to a greater or lesser degree depending on the number of GPS satellites it detects. This means that the appearance of the object changes when it is moved to different locations or from outdoors to indoors, and vice versa. This behaviour was revealed to the public in the gallery by a video showing different statuses of the sphere in a variety of places (from domestic lounges to flowery meadows). The video was needed to contextualise an object that is forced to be static for exhibition purposes, but designed to be handled and moved. Different from a text-based explicit...
making and constant re-assembling are an essential part of the performance. Haas’ goal is to maintain a typical of prototyping, to extreme levels. Indeed, its against each other’ (Bowers & Haas, 2014). Because of having its elements periodically rearranged, subtracted filament nylon so that they can swing, turn and bump no specification has been decided. A fixed order or organisational principle is neither achieved nor planned. The preference accorded to cardboard by the artist is significant of the desire to place the viewer in a particular mind-frame. While suggesting the idea of something temporary and ready to be dismissed or modified, the cardboard layers are meticulously laser cut and resist the impression of something rough or carelessly put together. This presents the viewer with conflicting aesthetic cues. It is precisely the joint effect of accurately calibrated ambiguity and adhocism (Jencks & Silver, 2013) that enables the imagination of the viewer engaged in the meaning-making activity around the artefact. Corrugations are objects for improvisations that remove conventions of use but demand alternative and subjective interpretation.

The idea of improvisation is crucial also for Annika Haas’ Sound Object (SO) (2013) and can be described as both a material and conceptual framework to explore the potential of touch in music performance. As an assemblage of heterogeneous loose elements (nothing is glued or soldered) producing sound through loudspeaker transducers, the object is not a musical instrument but rather a space to simultaneously design, research and perform. Nor is it a prototype, but something located at an earlier stage when a wider variety of directions of development are still open and no specification has been decided. A fixed order or organisational principle is neither achieved nor planned.

The SO consists essentially of a wooden base and a variable number of Petri dishes ‘attached by mono-filament nylon so that they can swing, turn and bump against each other’ (Bowers & Haas, 2014). Because of its proneness to be constantly manipulated, and having its elements periodically rearranged, subtracted or multiplied, the SO brings the notion of transience, typical of prototyping, to extreme levels. Indeed, its making and constant re-assembling are an essential part of the performance. Haas’ goal is to maintain a stronger relationship between the perceptual experience and the materiality and the visibility of the making process. By rejecting any cohesive arrangement and any artful intervention on the elements included as objets trouvés, the aesthetics of the SO reflects the correspondence between maker and materiality. This notion of the creative act as responsive to the materials and tools at disposal, as opposed to the imposition of a mental plan upon passive matter, resonates with Ingold’s critique of what he calls the ‘hylomorphic model of creativity’ (2013), that reads the outcome of a creative process backwards, as the imposition of a mental form on a passive material. Projects like the SO, instead, advance the idea of objects in flux, intrinsically and permanently unfinished.

In Pelvics (2014), Teresa Almeida revisits a range of medical devices for the assessment and the care of intimate parts of the female body. A series of ethnographic observations and a participatory workshop are the starting point for an act of literal deconstruction of the devices. The devices are displayed in a traditional exhibition display case, reframing them as museum objects belonging to a foreign cultural system. The project also includes an e-textile kit to encourage women in the regular practice of pelvic floor exercises, and a set of re-designed devices. The goal of the project is to re-inscribe new values and meanings onto the artefacts so that they could be more pleasurably appropriated and support women’s self-esteem. By questioning and re-designing stable and long-term marketed products, the project suggests how in an age of constant quest for improvement (van Geel, 2014) any product is potentially also a prototype for its own implemented, future versions. In this view, designed objects might never achieve a permanent condition, but rather live in a constant state of ambiguity between practices of use on one side, and their functioning as a base for further design. A further reason to include Pelvics in the Betagrams exhibitions concerns the idea of prototypes as objects for testing. In this case it is the very approach to testing and assessment in medical care that is questioned, suggesting a shift from quantitative and measurable factors to a diagnostic based on more subjective and experiential parameters, supported by touch and deeper contact with the self.
The ubiquity of testing in contemporary society is one of the key themes in Tom Schofield’s *Neurotic Armageddon Indicator (NAI)* (2013). The work visualises the Doomsday Clock, a symbolic clock maintained by an academic journal (*The Bulletin of Atomic Scientists*) that indicates our proximity to the nuclear holocaust expressed in minutes to midnight. The indicator scrapes the content of the bulletin home page as often as possible and sends the result to a red LED clock display. Since the Doomsday Clock is actually only rarely updated, at several year intervals, the programme performs a redundant and pointless act of verification. Its neurotic behaviour reminds us of Avital Ronell’s conceptualisation of the test drive as our society’s most typical obsessive compulsive disorder (2005). The NAI constantly performs an assessment; it frantically checks for results to nurture its compulsive need for scientific validity, but what it gathers is actually a lack of updates, an absence of confirmation. Conversely, this hyperbolic reiteration suggests the way scientific tests need to be repeated several times to acquire validity, and the way experimental truths tend to be only provisionally valid, always subject to be contradicted or made obsolete by subsequent tests. Furthermore, Schofield devised a second version of the indicator, making a participatory one that demands online users update the clock with the own apocalyptic predictions. NAI was included in the exhibition precisely because of how it materialises the interplay between iteration and testing.

Ben Freeth presented in *The Consolidator* (2014) the outcomes of a two-day workshop developed to question the meanings and values of data collection and its potential as a collective experience. After a speculation exercise on the possible functions of augmented reality goggles, participants were invited to assemble prototypes of wearable data loggers that featured bio sensors and way finders. These were deployed on the first day of the workshop to collect data during a psycho-geographic derive. On the second day the datasets were examined as tables, plotted as graphs, overlaid onto maps, sonified and printed as 3D models.

The 3D printed artefacts in particular are interesting especially because of their paradoxical relationship with the aesthetic of prototyping. Although their monochrome, bright, blue, plastic look and the deployment of only one material is typically associated with prototyping using rapid manufacturing tools, these artefacts are definitely not prototypes. In fact, they are not intended as a stage in the development of something else, but rather present themselves as independent objects or abstract landscapes to be contemplated as alternative topologies of the places explored during the derive. The relationship of these artefacts with the data they are meant to materialise is unreadable by a viewer in the gallery space. Instead, they present a mystery. This was a conscious decision by the artist, intended to replicate the same mechanism that accompanies the translation of the traces of a scientific experiment into its diagrammatic form, as described by Latour through his notion of inscription (1986, p.3). Indeed, scientific inscriptions result in visible forms that, alone, do not support their interpretation as facts. This is also true of the specific places where data has been collected, which can be viewed as abstract representations of reality.

Further, drawing upon contemporary scientific practice, the social dimension around the production of data and outcomes has been removed in the gallery as it is for scientific knowledge at the level of dissemination. By contrast, the processes and connections between experience, data and translated data have been extensively discussed during the workshop. In this light it is possible to point out how both the practices of prototyping and producing scientific knowledge are questioned by disconnecting their established aesthetics from their fundamental principles and raison d’être.

A recurrent feature of prototypical objects is their proneness to embed implicit action, practices or behaviours in their own material instantiations. This can be entirely left to the viewer imagination to articulate (such as in *Corrugations*), or alternatively directly provided by the designer with supportive materials, documentation, or even just the title of the work. The bomb presented by Diego Trujillo-Pisanty as *300 Years Time Bomb (300YTB)* (2012a) is accompanied by a fictional scenario that informs the public about the imaginary event of its discovery one hundred years after its manufacture (meaning that two hundred more years remain before its eventual explosion). This suggests a narrative developed around society’s changing relationship with artefacts and technologies, and our ability to put them under control and to turn them into material traces to be preserved and viewed as triggers of spectacular and affective experiences. Being set to explode in a future time that does not concern us directly, this piece not only alludes to non-human timescales, but exceptionally allows us to enjoy a dangerous object in its aesthetical features and with a sort of appreciative distance. At the same time, however, there is a conflicting feeling between the dramatic effect given by a running countdown and the awareness that we will not be there when it will reach the zero.

Trujillo-Pisanty also exhibited *Generated Man*...
innovative technologies or technological visions and deploy artefacts to test the social implications of prototypes. This last point is one of the driving principles of cultural probes and speculative design. Speculative experiments interpreted or appropriated by the public). This last point recurs in prototypical objects as both a topic or as a functional logic. Prototypes have been widely deployed in design and manufacturing industries to trial and assess hypotheses on unfinished products (Houde & Hill, 1997). Similarly, they can perform a test part as a creative object or an artistic endeavour. This can happen at three different levels: i) operational (to check if the code works as it should, if the device behaves as planned or if the object actually responds to the research question); ii) as an observable microcosm of interacting elements (to see how the system evolves without prior certainty about the outcomes); iii) at the level of reception (to explore people’s reactions to the object, the ways it is interpreted or appropriated by the public). This last point is one of the driving principles of cultural probes and speculative design. Speculative experiments deploy artefacts to test the social implications of innovative technologies or technological visions and often build complex fictional scenarios as testing environments developed around the artefact itself.

This directly links testability with fictionality (Corrugations, 300 YTB), that is the capacity of prototypical objects to embed or suggest a non actual but plausible system of values, practices or behaviours. Besides its role as an element of testing, fiction is more generally associated with the imaginative and interpretative activity encouraged in the viewer to make sense of the object by relating it to their own or other hypothetical world. Fictionality is the space where the future orientation of prototypes is projected, therefore it is not conceptually opposed to the notion of fact, but rather dialectically related to it. Fiction has little to do with fantasy in this context, but maintains a groundedness into scientific and technological research. When the fictional layer is the primary driver of a work, prototypical objects can be described as physical materialisations of stories.

A conventional design process might include several iterations (Pelvics, NAI, The Consolidator) of a prototype in order to explore different possibilities by breaking down the problem and addressing it under different angles. When creative artefacts are produced in practice based research, the interplay between theory, practice and evaluation develops into an iterative cycle to progressively refine the project and inform subsequent versions with previous results (Edmonds & Candy, 2010). Furthermore, prototypes can be regarded as matrices or originals that other users can appropriate, personalise or modify. Each modified version is an iteration generated within a public or collective dimension. An iterative approach to prototyping can be also associated with the playful experimentation typical of the maker mindset (Dougherty, 2013): making different versions and playing with a range of variables is part of an attitude to learning by doing, with the awareness that discoveries and new ideas might serendipitously emerge out of the process.

Prototypical artworks are often objects for critique (Corrugations, Pelvics, NAI, 300 YTB). Nevertheless, the use of prototypes for critique has been extensively discussed by speculative and critical designers who create hypothetical products to stimulate reflection and critical thinking around issues of technological innovation and consumerism (Dunne, 2008) (Beaver et al., 2009) for instance. In extreme synthesis, the key idea is that in front of a proposal for a future way of living, which is embodied in a prototype, people are forced to question the relationship between products, values and the idea itself of change. What is worth pointing out here is the aesthetic strategies that tend to support criticality. These include: the explicit display of the material infrastructure or substratus; the balance between openness and finishedness, ambiguity and richness of detail and stylistic definition, so that the object is perceived as plausible and relevant but also a subject to be questioned; the amount of information and documentation that accompany the object so that the viewer can properly refer it to specific issues.
Empiricism and Research

The lack of completeness of being of knowledge objects goes hand in hand with the dynamism of research. Only incomplete objects pose further questions, and only in considering objects as incomplete do scientists move forward with their work. (Knorr Cetina, 2001, p.185)

Knowledge objects can be problems, models or projects at the core of scientists’ activity. The way they are described by Karin Knorr-Cetina resonates remarkably with our notion of prototypes as dynamic, incomplete objects in a state of constant becoming. The role of the prototype in relation to knowledge production has been recognised in association with the notion of ‘boundary object’ (Subrahmanian et al., 2003). As part of a turn to practice in contemporary theory (Schatzki et al., 2001; Thrift, 2008), prototyping can be seen as a space where the interplay between making and materiality becomes more visible, leading to organic technical and conceptual understandings (Ernst, 2003; Kirschenbaum, 2008; Parikka, 2012).

Research environments with a focus on Human Computer Interaction or Interaction Design are increasingly generating artistic prototypes to bring knowledge forward (Gaver et al., 2004; Wilkie et al., 2010; Koskinen et al., 2011). In these contexts prototypes are adopted to embody theories or technical opportunities and to ‘include making as a method of inquiry in order to address wicked problems’ (Koskinen et al., 2011, p.4). An argument is advanced that when artistic objects are created as part of research activities, they tend to develop specific aesthetic features, different from those produced with museums, galleries or the marketplace in mind. The openness and instability of prototypical artworks is related to the fact that they are conceived as studies, ways to produce or generate knowledge, and therefore impossible to be rigidly enclosed in a stable configuration.

Making, Aesthetics and Prototypes: Final remarks

Some of the projects discussed in this paper demonstrate how the making process is seen as part of a continuity of aesthetic experience (Dewey, 2005; Ingold 2013). In the SO for instance, the assembling and disassembling of its various elements is already part of the musical performance. In this light it is possible to identify the impact of maker culture on the art world at two levels. First, it contributes to a model of public cultural event that includes the making as a key element (from labs to hackathons and so forth). Additionally, it encourages an approach that values the instability of the artefacts (with practices such as tinkering, recycling, and prototyping itself often used in maker spaces as an educational platform). If some of the artworks in Betagrams adopt materials and techniques closer to the world of craft and maker culture, such as cardboard, e-textiles and 3D-printing, it is important to recognise how the aesthetic of prototyping goes beyond specific stylistic choices and know-how. Rather, it embraces materiality as a framework where the aesthetic encounter is situated within experiential ecologies where the responsiveness of making practice to their materiality is explicit for both makers and audiences (Schofield, 2014).

This paper described how determined aesthetic solutions have been adopted by artists as a consequence of their work being developed as part of a research process, or simply within a research environment. The examples gathered through Betagrams are meant to delineate an emerging paradigm which is at the same time aesthetic and conceptual, that of prototyping. Because of its emerging character, such a paradigm needs to be challenged, provoked, and further corroborated. By proposing a new, cohesive and compelling way to address the relationship between making, aesthetics and knowledge the intention is to stimulate cross-disciplinary discussion that goes beyond the realm of research practices, towards a better understanding of objects cultural and material life, and perhaps unforeseen implications.

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References

THEME: DEMOCRATISING TECHNOLOGY


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Digital Jewellery: The democratisation of authorship and ownership

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Introduction
This paper explores jewellery that has been enabled by the advent of digital technology and computer-aided design and manufacture (CAD/CAM), analysing the extent to which authorship and ownership may have been democratised through these digital means. It identifies the ramifications of digital manufacture and the internet upon jewellery design and contemporary jewellery through an examination of the respective roles of the jewellery designer, contemporary jeweller and consumer. These are sequentially analysed through the initial stages of jewellery including design, production and consumption. In so doing, the paper aims to ascertain if and how the authorial act of creating jewellery has been democratised through digital manufacture and delivery. A complementary investigation seeks to establish whether ownership has been democratised through a reduction in production costs and online distribution.

The notion of democratising access is not necessarily new, for in its origins jewellery was probably as simple as a threaded shell or found object. (Bernabei, 2011, p.2) After centuries of increasing technical sophistication in metalsmithing and stone setting, a desire to return to the rudimentary, easily available and low cost origins accompanied the post war emergence of new European approaches to jewellery. One early innovator was Margaret de Patta, who in 1946 started ‘creating prototypes that could be produced at lower prices’ (Cartlidge, 1985, p.75). As ideas coalesced further in the 1960s and 1970s through the movement commonly known as Contemporary Jewellery, certain jewellers even encouraged or demanded that the consumer become an agent of design through the selection and matching of multi-component works, as in the ring sets by Wendy Ramshaw. Works such as her 1971 Ring Set, encompassed five rings in gold, enamel, dyed acrylic, cornelians and amethysts were shown on a stand that was an integral part of the work. This enabled the consumer to view the rings before deciding how many and which rings to wear, as well as whereabouts on the hand they should be positioned. Whilst Ramshaw established the design of the components, the final composition was literally and metaphorically in the hands of the consumer. Outcomes also extended to an explicitly acknowledged exchange of roles between author and consumer through works such as Louis Martin’s Make Your Own Brooch, 1974, which as the title suggests, required the consumer to actually create the jewellery

Abstract
The paper analyses the consequences of computer-aided design and manufacture (CAD/CAM) on the authorship and ownership of contemporary jewellery. It identifies the ramifications for jewellery design and contemporary jewellery through an examination of the respective roles of the jewellery designer, contemporary jeweller and consumer. The latter focuses on the extent to which individual members of the public can become virtual craftspeople. It therefore aims to ascertain if and how the act of creating jewellery has been democratised through digital manufacture and delivery. A complementary investigation seeks to establish how far CAD/CAM has enabled contemporary jewellers to democratise the consumption of artistic jewellery through a reduction in production costs. Analyses chart CAD’s gradual shift from exclusive use by expert technicians to generic deployment by amateurs manipulating user-friendly and intuitive software. They determine how its unification through web delivery in apps by companies such as Nervous Systems, effectively converts consumers into designers. Parallel investigations explore the work of jewellery artists such as Ted Noten and Christoph Zellweger who have exploited CAD/CAM to mass produce works that democratise consumption through lower purchase prices.

The paper concludes by summarising the key differences and similarities between the artistic use of CAD/CAM in jewellery with those of its more commercial and design orientated counterparts. It determines the relative shifts over time in both parties’ respective roles since the inception of digital technologies, identifying convergences and divergences. Finally, it assesses the relative merits of both approaches in terms of democratising ownership and authorship, as well as the consequences for aesthetic integrity.

Keywords: Jewellery, democratisation, CAD/CAM.
from the supplied kit of a perforated aluminium form and pipe cleaners. Instructions were supplied, but the final design was chosen by the consumer turned maker. Louis Martin describes the work going on in Holland at the time as ‘art without pretensions to uniqueness, democracy through a stress on the concept instead of materials’ (Martin, 1995, p.52). The action ‘to make’ shifted ‘to chew’ with Ted Noten’s participatory Chew Your Own Brooch, 1998. Buyers received a stick of chewing gum to be chewed into a form that was then cast into metal and transformed into a pin brooch. Allied to the emergence of these practical intentions to democratise jewellery, as noted by den Betsen, were the views of the French theorist Roland Barthes in 1961, with his essay ‘From Gemstones to Jewellery’, where he describes the liberalisation of jewellery. (den Besten, 2011, p.22)

If the basic foundations for democratising authorship and ownership were laid during the latter half of the twentieth century, potential fruition may have been enabled by the accelerated development of digital technologies, including the advent of widespread computer-aided design and computer-aided manufacture (CAD/CAM), as well as the internet. Presently, jewellers have multiple software options for the virtual design of jewellery. GemVision’s Counter Sketch Studio, allows a library of wedding and engagement rings to be altered in front of the customer prior to passing the resulting file for manufacture to partner company Stuller. In light of these new technologies, the following sections analyse the extent to which they have broadened the customer base for jewellery and how meaningfully they allow consumers to design jewellery.

Democratising Design
The first stage of creating jewellery entails its conception and design. Invariably the consumer was previously an infrequent influence, unless seeking bespoke commissioning. The democratisation of authorship is analogous to the consumer customisation of design and production, and in particular design because digital production is often machine led. The advance of digital technology and the internet has increased the possibilities for the consumer to be innately involved in the design process and this has resulted in varying levels of personalisation. According to Lionel T Dean, academic and designer of 3D printed artefacts, these levels can be categorised as ‘Individualisation, Personalisation and Full Customisation’ (Molitch-Hou, 2014). Dean asserts that the control of the consumer over design ranges from basic through to complete. With 3D printing a key facilitator, it is uniquely suited to what Dean describes as ‘mass individualisation’, arguing that ‘it costs the same amount of money to produce similar parts as identical ones using rapid prototyping, so why produce two products that are the same?’ (Marshall et al., 2008, p.42)

At the most basic level, the extent of choice is synonymous with that offered by traditional jewellers, with variations including engraving, stone and metal selection, as well as physical dimensions. Whilst made available through websites, manufacture relies on traditional modes of production at the jeweller’s bench; meaning distribution is digital, but manufacture remains analogue. A pertinent example is Jewlr, who allow consumers to progress through a series of web pages, each offering a design choice that contributes to the overall look and composition of the jewellery. Much in the same way many websites offer consumer services with add-ons that can be accepted or rejected. This helps create a familiar pathway to completion and purchase.

A more interactive development, akin to Dean’s notion of personalisation, has resulted from the creation of software applets or apps, which have allowed mainstream mass production to become personalised in a manner that was previously less widespread and less feasible. Indeed, a potential shift from the designer as author to the consumer as author has consequently been made possible. At the intermediate level of consumer input apps such as those offered by Suuz and Zazzy allow consumers to choose a word or words that define the geometry of their jewellery. The software is instantly responsive, meaning visual feedback confirms on screen how a given word will look once manufactured. Text is immediately converted into the band that creates a ring or a cursive strip of mass for another typology of jewellery, such as a pendant.

Tellingly, the tagline on Zazzy’s website is ‘You do the chic, we do the geek’, meaning the consumer is free to design, but remains liberated from the taxing demands of manufacture. A similar driver of design can be the use of initials to create a monogrammed outcome, as in the service offered by Mymo. Two initials are merged into a single form, with each remaining distinct from different viewing angles. Another option for personalisation is enabled via the upload of images that then dictate geometry, for example Suuz also provide a service whereby a photographic facial profile becomes a planar ring’s silhouette. Most of these websites seek to enhance options for personalisation by allowing ring and bracelet size to be altered, font type and material thickness to change, as well as some choice over materials and finish. They seek to do so in the most simple and visually responsive manner possible, often through the use of sliders in the apps that can be moved up or down. In other words, the technical skill required to use these apps and websites is minimal and the representation of consumer’s changes is instantaneous. The final fillip for ease of use and purchase is that all these products are then manufactured and delivered direct to the consumer’s home.

A similar pathway is offered by Shapeways, the online 3D printing bureau, who offer a range of jewellery apps that aid the personalisation of a design. From the relatively simple, based on text, through to the more geometrically complex Turks Head Knot. Alternatively, the Italian company Makoo offers an
innovation in personalisation through speech or sounds. Personal sentiments can be spoken into the computer and their software transforms the captured sound waves into modulated form. Users can then further deform and disrupt the form using sliders.

Despite these innovations in the consumer input required to design jewellery, these modes of production are confined to predefined parameters of possibility. Whilst consumers’ arrangement and composition may be genuine, the scope for expressive design is limited. For greater input, one needs to look towards those companies who incorporate generative algorithms into their apps, in order to effectively grow forms. Nervous Systems’ might be considered an exemplar of unifying creative software, online delivery and bespoke production. The latter is implemented through simple, user-friendly applets that allow people to create complex forms by manipulating sliders and numeric counters for various parameters. Visual feedback is immediate and the resulting forms are abstract and being devoid of text or obviously personal references may even give the impression of having been designed by a professional, rather than the consumer.6

Co-founded by Jesse Louis-Rosenberg and Jessica Rosenkrantz, Nervous Systems provides evidence of how software, such as their Kinematics, Cell Cycle and Radiolaria applets, may help transform members of the public into virtual craftpeople. In this sense, the company’s design creativity resides in coding the systems that allow the jewellery to be created, but its final manifestation is determined by others. It is intriguing that within the remit of personalisation that, according to Louis-Rosenberg (2014), ‘there is no definitive product; instead, the many designs created allow for mass customisation’. Going on to explain that ‘designed algorithmically requires manufacturing digitally’, making it ‘a very good way to explore the concept of repetition because it is just as easy to make many things as one thing. It allows the possibility of infinite variability for the same reason’ (Louis-Rosenberg, 2008). This variability confers considerable choice for those using the applets. Louis-Rosenberg believes this less to be a distinct aspiration than an innate consequence of digital production, stating that ‘the ability to abstract your process and create a user interface also encourages interactivity and customisation’ (ibid.).

Consumers’ completed designs are then manufactured by Shapeways, which makes a wide range of materials, colours and finishes available for selection. This shifts Nervous Systems’ output further towards the notion of Full Customisation’ outlined by Lionel T Dean. It cannot, however, provide full customisation given that the programmers define the apps and set the parameters of ‘look’, if not the exact details of geometry and material. It does become a paradigm of what the art historian Susanne Ramljak describes as ‘Prosumerism’. Outlined in her essay ‘A Touchy Affair: On contemporary and commercial jewelry’, where she discusses ‘hybrids of production and consumption... a cross between producer and consumer behaviours’ (Skinner, 2013, p.216-17). I would argue this may become a kind of self-fulfilling prophecy in which demand for personalisation from customers will increase until bespoke becomes a norm at all market levels. Key to this may well be the increased dispersion, affordability and usability of computer-aided manufacture, as will be discussed in the following section.

Democratising Production

Once design has been finalised the inevitable next step is its production, and in this context there appear to be two potential strands for the democratisation of authorship through digital technologies. The first concerns the consumer turning creator in an act of DIY craft, and a second, whereby digital design requires machine manufacture. Both have consequences on craftsmanship and the extent to which traditional making skills are required.

For those consumers with some basic software knowledge there is a proliferation of online manufacturing bureaus offering 3D printing, laser cutting, laser etching and digital photo etching. Costs are fixed pro-rata according to volume or area, and pricing is automatically revealed on file upload. This, along with the increasing user-friendliness of CAD software, means ease of use is becoming a reality. Access to expensive equipment is democratised through collective contribution. With this access and ease of process, the argument then goes, why pay someone else to design jewellery for you, when you, as the consumer can become the designer and create your own fully customised jewellery? These websites are answering that question through the digital manufacture of jewellery with home delivery; meaning that the distinction between amateur and professional is softening. Furthermore, when so doing, the consumer is no longer confined to the preordained parameters set by the aforementioned apps.

Examples include Ponoko9, who enable images or illustrator files to be laser cut from plastic or other materials and Shapeways, who offer the 3D printing of materials including metals, wax, plastics and ceramics. Shapeways are clearly seeking a global market, offering a worldwide service, as well as creating an online community of makers and designers through their galleries, forums, blog and individual users’ shops. Not only can a user’s work be manufactured, their designs can be offered for sale to all, with the added bonus of not having to invest heavily in stock thanks to print on demand.10 Shapeways simultaneously enable complex production and promote worldwide sales. It may appear that traditional making skills are being negated, and one might argue that this in turn means production becomes democratised by being made available to all because the machine creates the object.

The counter argument suggests that despite machine printing jewellery the extent to which skill is
still required essentially correlates to the aesthetic and geometric complexity of the resulting jewellery. In other words, digital technology is no panacea and whilst in this ambit there may have been a shift from traditional hand making skills to digital production, the necessity to acquire and hone high levels of craftsmanship persists. It just pertains to the digital realm of computer-aided design, for that is where the geometry and aesthetic of the jewellery is primarily decided, even if some post-production does occur after 3D printing.

Support for this notion of digital excellence is provided by those jewellers who appear to have developed a high level of digital design acumen. Exemplars include Joshua Demonte, who creates architectonic headdresses and other body pieces of considerable scale and intrigue. Stefania Lucchetta prints in metal by exploiting Direct Metal Laser Sintering (DMLS) to create tightly latticed forms in titanium that would be extremely challenging to hand manufacture. Along with Dorry Hsu, who exploits Stereolithography (SLA) to create complex and translucent animal-like forms. One might argue that the geometric accuracy of 3D printing means that even professionals are excused the need for hand skills. Therefore, access to the manifestation of complex forms is open to anyone, so long as they have the skills to model in CAD. Thereafter, digital solutions can also assist the transition to marketplace, as will be investigated in the following section of the paper.

Democratising Consumption

In pre-digital times jewellery would traditionally have been distributed and sold through networks of shops, traders, catalogues and galleries. As previously discussed, the digital realm has enabled production and distribution to merge through a union of the internet and computer-aided manufacture, as amply demonstrated by Shapeways. Digital manufacturing has also had consequences upon contemporary jewellery and its tendency to favour one-off pieces. Perhaps the biggest revolution in terms of democratising access to artist produced jewellery has been the reduced unit cost that CAM technologies such as 3D printing, laser cutting and digital photo-etching can procure. Lower prices steer these pieces of jewellery away from high-end objects of desire towards accessible and more readily purchasable items, where the quality of design is not reduced by lower prices. As Jesse Louis-Rosenberg of Nervous Systems notes, ‘we make very affordable things. If I make something that costs $10 to $20 then I can sell that to basically anyone’ (Substratumseries.com, 2011). This relative affordability extends to some recent work by contemporary jewellers such as Christoph Zellweger, Ted Noten and Noon Passama. As well as lowering production costs, the innate reproducibility of digital designs lends itself to serial production as limited or unlimited editions. These jewellers therefore appear to build on the democratic aspirations of earlier multiples that were embedded in the ‘utopian vision of the sixties and seventies’ (Ober, 1978, p.24) A period when mass-produced components were used to aid cost reduction, as in Charlotte van der Waal’s Suitcase Snap Bracelet (1972); composed of two parts with suitcase snaps so consumers could easily select different colours. Subsequently, Dutch jewellers Lous Martin and Hans Appenzeller produced Serie Sieraad a series of twenty-three inexpensive editions between 1973 and 1974 with the ambition of broad dissemination through affordable prices. Despite the democratic aims, according to Appenzeller, the results suggested that endless cheap copies were not the solution, stating that ‘if you want to conquer the market with a rubber bracelet in 1973, you’d better off making ten than a hundred’ (Martin, 1995, p.52). Dutch consumers seemingly accorded value to the prestige of one-off or tightly limited production at that time. Perhaps their works might have achieved more widespread success had they been produced in the digital age, in which worldwide publicity is a real possibility.

An early example that exploits digital manufacture is Christoph Zellweger’s Data Jewels (2001), digitally photo-etched from thin sheets of stainless steel to create pendants. He outlines the development by explaining how ‘in 1998, I experimented with a program called Processing, which finally led to the work Data Jewels, work I produced industrially in stainless steel but developed on AutoCAD. It was a first attempt to create easy wearable jewellery that can carry individually customised information. The ornaments referred to the kind of chips found in credit cards, or to QR codes or patterns on circuit-boards, yet at the same time some aspects in the design appeared organic’ (Zellweger, 2014). In this context, Data Jewels was a forerunner to the subsequent emergence of Nervous Systems, a paradigm of its commissioner’s (Chi ha paura…?) aspiration to create designs of intelligence that can be made relatively affordably through serial production. Finally, Zellweger’s work also constitutes a predecessor for Ramljak’s Prosumerism concept.

The next example concerns the elegant and elemental 3D printed brooches Extra Button, Edition III, (2011), by Noon Passama. These offer both the artist and consumer a range of finishes from sprayed to electroplated, meaning digital production contributes to works that are both customisable and affordable; notwithstanding their luxurious appearance (den Besten, 2011, p.26).

The exploitation of the relatively low cost of 3D printing can also enable projects in which consumer participation becomes vital to its success. Ted Noten’s Wanna Swap Your Ring. (2010) Tokyo project involved the production of 300 3D printed Miss Piggy Rings, which were then hung on nails arranged in the shape of a gun and offered to viewers willing to exchange one for a piece of their own jewellery. Over the course of the installation the work shifted from an unadulterated plethora of Noten rings to a panoply of...
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12. www.stjamescrossrevisited.com


14. www.youmagine.com

15. www.thingiverse.com

16. Maplin now sell plug and play 3D printers for under £700.

17. www.thingiverse.com/thing:290279

jewellery of different kinds, styles, aesthetics, materials and value that came to represent the host city. The low cost of digital production meant producing and exchanging so many copies of the same ring became financially viable; essentially democratising access to Noten's work. It is a possibility that evidently appeals to Noten, given he previously created the laser cut pin, St James Cross Revisited, (2005). A large edition of 1500, each costing roughly £20, and also constituted an early exploitation of a website for the purposes of promotion, distribution and 'conceptual completion' of the work. The latter because its dedicated website allows consumers to upload images of their edition being worn or placed in a setting of their choice.12

Another way in which consumers can actively contribute to increasing access to innovative jewellery is crowdfunding. In exchange for pledges of money, consumers receive samples according to their level of support. Examples include Human Chromosome Jewellery, (2014), by Louise Hughes.13 Whilst consumers admittedly receive jewellery or related artefacts in exchange for donation, they effectively buy into the idea of the work, becoming involved in design and production by proxy. Consequently, patronage democratises community ownership. This seems particularly beneficial to Josh Harker whose various projects to fund sculpture and body ornaments were oversubscribed on Kick-starter. Clearly an advocate, he reveals his belief that 'Crowdfunding is democracy at its core. It provides public empowerment through participation' (Harker 2012).

The final possibility for the digital democratisation of ownership concerns the emergence of website repositories such as YouMagine14 and Thingiverse15 that store, collate and freely offer uploaded 3D files for download and printing. Submission requires acceptance of creative commons licence and the relinquishing of copyright and authorship. This effectively means consumers need only pay for production costs with a bureau of their choosing. Or, should they have a home printer, print it themselves. Given the falling costs of purchasing a machine, this will be an avenue increasingly open to more consumers.16 In a paradigm of open access, MakerBot's Thingiverse community has designers freely distributing customisable ring software for use with a MakerBot 3D printer.17 The contemporary jeweller Christoph Zellweger believes this has potential for innovation given that he already observes 'wonderful ideas (as downloadable files for print out) coming from sensitive jewellery designers and artists that are studying now. Intelligent and beautiful pieces I can print out before a dinner party that I will wear again and again' (Zellweger, 2014). At the same time he cautions against over production and the need for greater development of three dimensional forms and jewellery with embedded content. Stating that designs tend to be 'limited and often lack quality on many levels, especially when it comes to the final surface finishing. Designs are still very flat. We also need more designers and artist who use the technologies available to develop intelligent and forward looking products that express strong ideas based on sound concepts; ideas that go beyond building aesthetic variations, ideas that are focused on content too.' (Zellweger, 2014)

Conclusions
There can be little doubt that digital technologies have revolutionised how jewellery can be designed, produced, distributed and sold. The question remains as to whether these developments have democratised authorship and ownership, and if so, the extent to which this may have occurred. The potential for consumers to meaningfully contribute to design and production is mixed. Whilst company websites, including Suuz, allow for design individualisation, the extent of customisation is somewhat limited, with consumers selecting from a palette of options to build a package. Increased consumer input is facilitated by the apps of companies such as Nervous Systems and Shapeways. However, setting the parameters of design is beyond the consumer. Instead, much of the creativity resides with those who programme the code to produce the apps, for they determine the parameters of aesthetics through which the jewellery can emerge. This even applies to the generative apps developed by Nervous Systems, which seemingly allow consumers to grow their own jewellery in CAD. The look of the pieces is pre-defined, if not the details of size, material and precise geometry; so the consumer experience is still restricted by what the designers have conceived. That said, these apps do appear to put a degree of creative potential within reach of most consumers, without the need for acquiring extensive technical knowledge or making skills.

Overall, it may be surmised that democratisation has begun, and for those willing to participate, there is potential for the amateur to seemingly act like the professional. These sites offer services that are the first steps towards broad consumer participation in the design process. However, the notion of total customisation remains a mirage. If you wish to master design in the digital realm, you are required to develop an extensive skill set of digital modelling techniques. In terms of production, digital manufacture has to a degree, induced what I describe as 'technical liberation'. By which I mean that 3D printers' ability to accurately replicate complex geometry can supersede the need for handicraft. Makers are liberated from the extents of their technical skills and bound only by their ability to model in CAD. This applies across the board to both professional users and amateur consumers. Indeed, the latter have amplified DIY jewellery through prosumerism: a cross between producer and consumer behaviour. Aided by online distribution, access to complex and expensive equipment has been facilitated through the collective usage of multiple individuals, be they amateur or professional. It is perhaps for consumption that digital
technologies have done most to democratise access: partly through the decreased cost per unit and partly through internet sales, distribution and promotion. Contemporary jewellers have sought to harness digital technology to extend the language of jewellery, as exemplified by Christoph Zellweger’s Data Jewels and Ted Noten’s Wanna Swap your Ring. Allied to the fiscal means to purchase, consumers have also benefited from easy access to new work through the websites of organisations like Chi ha paura…? or Shapeways. Each in their own way has also promoted contemporary jewellery to a wider audience, which itself is a form of democratisation. Shapeways has taken this further through their community forums, where community creators can exchange ideas and tips for designing and making.

In conclusion, I maintain that the democratisation of authorship has commenced due to the advance of digital technology, yet its further progression relies on increasing the user-friendliness of CAD software. Otherwise, design will remain a collaboration between the consumer and those who create the jewellery ap or software. In contrast, ownership has become more democratised and therefore leads the way to innovation, which authorship may follow in due course. Nonetheless, digital technologies appear to have democratised access to jewellery, its techniques and subsequent acquisition.

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Roberta Bernabei is a jewellery maker and historian whose work has been exhibited at various national and international venues, including Birmingham Museum and Art Gallery; Victoria & Albert Museum; National Museum of Modern Art, Tokyo; and the Museums of Decorative Arts in Berlin and Turin. In addition to institutional hosts, her jewellery has been featured in various private and commercial galleries, as well as entering both private and public collections; the latter including Birmingham Museums and Art Gallery; Bilston Craft Gallery; Museo del Gioiello, Padua, Italy; and Museum of Contemporary Craft, Portland, Oregon, USA.

Since 1989, she has shown her jewellery throughout Europe; largely exploring body decoration issues through a wide range of media. Her recent studio practice has shifted emphasis to explore digital technologies and how they may be seamlessly united with traditional goldsmith techniques, including the manipulation of CAD/CAM, rapid prototyping, precision photo etching and digital embroidery. Attempts are currently being made to humanise the ‘perfection’ of digital manufacture through hand finishing, subverting intended materials and incorporating visual and tactile illusions.

Roberta has chaired several exhibition panels and conferences including the annual Conference of the Italian Association for Contemporary Jewellery in Trieste; Juror of “Eine Handvoll Glasperlen” jewellery competition organised by Museum Iuer Weltkulturen, Frankfurt; and most recently, as a member of the selection panel for LUSTRE, the Contemporary Applied Art fair held at Lakeside Arts Centre in Nottingham.
The course, BA Jewellery and Silversmithing at Edinburgh College of Art, is a four-year undergraduate course with an international reputation as one of the UK's most highly regarded courses to study this craft-based subject.

**Limited Edition; Stephen Bottomley**

Limited Edition is a third year live project introduced in 2009 by Stephen Bottomley when he started in Edinburgh as Head of Department. For the past five years the project objectives have been to introduce students to the available range of methods of digital design and manufacture. In this time, the students have become more digitally literate and open to the idea that digital design and manufacture can enhance their hand making studio practice without replacing it.

This live, industry placed project involves the students working collaboratively, both internally with other design students at ECA, and externally with the excellent computer aided design (CAD) team at Weston Beamor in Birmingham, which is one of Europe's leading casting and Rapid Prototyping (RP) jewellery specialists.

The project brief is to create a limited edition batch production run of at least ten pieces of work that utilises CAD and manufacture working with Weston Beamor’s casting, and their sister company, Domino, for RP facilities.

A study visit to the factory is important both to meet the manufacturers and understand the process from an industrial and commercial perspective, which underlie the LIVE nature of the project (Image 1). It is written into the agreement with Weston Beamor that the students will receive two rapid prototyped CAD models back for evaluation. It is important they receive their first model and have time to evaluate it and make changes to either the digital file or the actual model before moulding the pieces for reproduction and final production.

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**Abstract**

This paper explores the current craft practices and ethos of academic craft makers within the Design School at Edinburgh College of Art / The University of Edinburgh. Edinburgh College of Art (ECA) has had a strong virtuous tradition of studio-based practice dating back to the 18th Century and now, with an increasing community of digitally versed makers, practices go beneath a material surface to investigate shared themes of production, narrative and memory.

How are digital methodologies being introduced to traditional studio based craft programs like Glass, Jewellery and Silversmithing by subject practitioners (Bottomley and Gray) and applied by their new emerging makers?

Have values of craftsmanship altered when operating in the territory between craft culture and digital making?

To explore these questions the philosophical approaches to research and practice of Bottomley and Gray to research and practice, will be examined in relation to the academic curricula they shape through projects and post-graduate research at ECA. This paper will demonstrate how the digital alone cannot deliver polished and beautiful finished products and recognise the importance of integrating essential hand skills and tacit material knowledge with the use of modern digital technologies.

**Keywords:** Integration, (im)-materiality, practice-led teaching.
casting in metal. Only a short, limited, but focussed period of bench work is available at the end of the semester before the work is due for exhibition and for sale. This puts pressure on the students to think cleverly about their design and ensure there is little arduous post-production finishing.

Students, over the course of the first 15-week semester in year three, are exposed to a complete design cycle; from the research and design, to prototypes and final pieces (Image 2). The design development is achieved through a combination of hand drawing and 3D modelling that is run in parallel with small refresher master classes in CAD, run by Kathryn Hinton.

Importantly, the digital design drawings are often done whilst working from analogue, hand-made models in wood, plastic or metal. This is a low-tech / high-tech approach to integrating digital skills with the traditional studio based craft skills taught on the Jewellery and Silversmithing program. It lays equal importance on each process feeding the other and supports the existence of a ‘close relationship between digital work and craft practice’ (McCullough, 1998).

Time management is an important feature of the project with students at the start of the project not only knowing the deadline and the date of the show, but also the first date the original CAD file must be with the RP company Domino, for the first prototype (Image 3). The date to have the final design confirmed for moulding and casting in metal is also scheduled so they can anticipate when they are likely to have the castings back at the studio in time for assembly (Image 4).

Importantly, students learn to cost and value their time while working to these deadlines and appreciate that they may need to collaborate as a designer with industry to achieve commercial work with a broader market rather than as they would with making one-off, bespoke, gallery jewellery. Working to tight parameters or constraints is an important design challenge to master.

Balancing the drive for a commercial exhibition / sale with the project’s aim to encourage students to explore the digital process for making forms that might otherwise be too time consuming or difficult to hand make, is an accepted part of the project that always leads to interesting discussions at critiques and reviews. A balance is often successfully found and the project is one where the majority of students cover all their costs and even make a profit.

Interdisciplinary collaborations have developed exciting partnerships between Product Design students who formed teams to develop design concepts and, more recently, Graphic Design students who ran a parallel packaging project with the jewellery students as their clients (Image 5).

Reflecting on the work of the past five years and the sixty or so students who have been through this project, and questioning if the values of craftsmanship have altered through operating in the territory between craft culture and digital making, it is clear that digital technologies have added a great deal to the existing toolkit of skills a designer/maker has available. Shillito presents digital technologies as tools to be mastered, the same as any other tool in a makers ‘toolbox’ but qualifies this by saying:

However, as being ‘digital’ means the processing part is ‘hidden’, making understanding and controlling the process from concept to end product seem more complicated, unfamiliar… and definitely not craft. (Shillito, 2013, p.9)

The values of making objects well and achieving high standards of design and making are still as important today as in the past. Work, like the jewellery of MA graduate Alice Bo-Wen Chang, reflects her previous training as an architect and confidence with the computer software she used to design windows and cladding for skyscrapers (Image 6). The scale has changed, and in this piece of 2011, Chang cleverly used the small prototyped and silver castings as kinetic puzzle pieces that could slide around on the larger hand cut frame they occupied.
Recent developments have seen students literally breaking the mould of the casting size limitations imposed by Weston Beamor and are now exploring sintering technologies with companies like Shapeways who work with with Cooksons Gold. Who have installed three gold sintering machines at their Birmingham factory in 2013. This year the students also designed jewellery to be sintered on these machines (Image 7). For the first time they ran a national competition and one of our student’s designs was made and exhibited by the company at national trade fairs.¹

Analogue AND Digital; Jennifer Gray

With reference to my own research into ways of using traditional hand skills alongside modern 3D digital technologies, I will discuss my reasons for advocating that students have the opportunity to learn these combined methods in all relevant disciplines.

Digital technologies available to a maker today present new opportunities never before possible in the pre-digital past. Objects are now being created which would just not have been feasible before the introduction of 3D printing and digital model making software. Digital technologies alone cannot deliver polished and beautiful finished products. In some instances new digital technologies are hailed as the complete answer or solution, but they are really just a means by which one can start to explore new possibilities and are certainly not inherently creative in themselves. We should think of the digital as part of a toolkit to be used alongside other skills. It is important for institutional departments to ensure that essential hand-skills and tacit material knowledge will never be lost, but rather complimented through the use of modern digital technologies.

Glenn Adamson, when speaking about the integrated use of digital methods is quoted as saying:

_The ones to watch are those who see clearly that its value is only contingent – that it requires a considerable amount of buttressing to have a significant effect. While the digital does depend, ultimately, on the analogue, the contrary is true as well._ (Adamson, 2013, p.171)

At ECA we aim to integrate new digital tools gradually after the student has developed a basic grounding in the key materials and techniques of their departmental discipline. They will eventually be skilled enough in both to confidently move between analogue and digital and not rely solely on one or the other, thus allowing them to develop their own material/technical identity.

I began professional life as a jeweller/silversmith in 2006. Carving and lost wax casting were amongst my core skills. During this time, if a job required me to repeat a product in a different scale or with a slight variation of form, I would have had to re-carve a completely new piece, costing further time as well as the client’s money (Image 8).

I became interested in digital technologies because it offered the possibility to scale and easily repeat models, enhancing design possibilities and in turn expanding my market. In the past I was often quite put off by the prospect of having to learn modeling packages such as Rhino – which was the main 3D modeling program available to learn at this time. I just couldn’t see how learning this engineering style package might relate to, or enhance my studio work or the making experience that I had spent so many years developing.

I eventually found what I was looking for in a 3D modeling package called Z Brush which allowed me to continue ‘carving’ in the virtual realm. It was to become my main stepping stone towards embracing digital technologies and a point from which I could understand the benefits of familiarising myself with further software packages.

The tools in this program are specifically devised to duplicate my real tool kit. I could still use my pre-existing skills and using digital technologies didn’t mean having to retrain completely. I could just adapt.

To carve wax I rely on my eyes to examine my
subject and my hands to remove material with steel hand tools. The same methods are utilised when carving virtually. As far as possible, I use manual settings when carving my models in Zbrush so they appear similar to my hand carved forms (Images 9-11).

A virtual block of wax appears on my computer screen and I carve it as you would by hand. Using this method, I substitute my steel wax carving tools with a USB drawing tablet. The final models are 3D printed in Objet resin or Zcorp, manipulated further, then cast in other materials.

Encouraged by my successes with digital carving and 3D printing, I polished up on Rhino and learned to use other 3D packages. I realised more could be gained through working with a full range of software packages, just the same as I would use a full range of tools and machinery to make my work in the workshop. I developed a way of using digital technology that felt quite natural for me and my way of working.

Sometimes I carve then I scan, manipulate digitally, then combine with hand-fabricated elements. In other instances I will carve, 3D print, then re-carve by hand. I tool then retool the objects both in virtual and real workspaces (Image 12).

Personally, I feel that 3D printing materials, at this point in time, couldn’t replace the general aesthetics and qualities of the wood, metal, plastic and stone I currently use in my final works. They still require hand finishing or re-working into another material. At this time 3D printing materials are still a step behind the digital modelling packages and tools. I use the 3D printed models purely as part of my design and making processes.

Using further hand-made and digital processes, my final models are produced in various materials to suit their ultimate purpose (Image 13). I also use this technology to 3D print parts of my work which I can then out-source to practitioners of other disciplines. For example, I hire a ceramicist to slip cast large hollow vessels for me.

I model the 3D object to the exact required scale in programs such as Rhino, print it, mould from it and then hand it over to the ceramicist to slip cast in porcelain. Before this technology was available the ceramicist would have had to make moulds from my design drawings, and there would be no guarantee that they would turn out exactly as I wanted them. Today I am, in essence, making the item in a virtual realm so the artisan can realize it in his or her own material to the millimetre. I can then be reassured that my work will have both the quality and aesthetic consistency that I require.

This work would not be possible without my experience of both traditional and current digital methods. I aspire to produce work that can leave the viewer uncertain as to how it was made. I hope to
Bottomley, S. & Gray, J. demonstrate that technological approaches and traditional methods can blend quite naturally together in a piece of work.

In some of the work produced by our current degree and postgraduate students it has been encouraging to see that each has used digital processes which compliment their studio work rather than define it (Images 26–34).

In the recent Design Commission report into embedding growth through design, innovation and technology in education they say that:

*In order for ‘digital making’ to be embedded properly within the curriculum, it must be fused with ‘physical making’ skills. We must end the simplistic assumptions that it is easy to design something on a computer using CAD, or that young people are no longer interested in building with their hands and using basic tools.* (The Design Commission, 2014, p.46)

With this in mind, it is our aim to produce dynamic, mindful makers and problem solvers with hand skills that enable them to continue honing and making where 3D technology ends. People, and excellence in the work they produce, should be the sole centre of our attention and not simply the digital processes used in its making.

References:

Stephen Bottomley trained at the Royal College of Art (MPhil RCA 1999-2001) and the University of Brighton (MA 1996-98) which included an exchange to Rhode Island School of Design (USA 1998). Academically he has directed degree programmes at Hastings College of Art, Sheffield Hallam University and currently leads the MA, MFA and BA Jewellery and Silversmithing programmes at Edinburgh College of Art / The University of Edinburgh. As a maker his business was established in 1990 and his work is internationally exhibited and held in several major collections including the National Museums of Scotland and the British Museum, London.

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Photographs remain important evocative reminders of social experiences and history. Research in community-based design has highlighted the relevance of photo-sharing, particularly around local heritage to support informal learning opportunities to perform rights of passage for the uninitiated and support membership (Carroll & Rossen, 2013; Taylor et al., 2009). As digital photographic collections both proliferate and age, this creates opportunities for groups to collectively sustain participation in contributing, organising and meaning making associated with images (Gulotta et al., 2013; Odom et al., 2012). While an abundance of online tools and social network sites offer particular ways of organising content, researchers have also looked towards the use of physical objects, mementos and materials to create alternative opportunities for meaningful rich social interactions around sharing digital media (Ciolfi et al., 2012; Durrant et al., 2013; Nunes et al., 2009; Petrelli & Whittaker, 2012; Wallace et al., 2012 & 2013, White et al., 2013). The context for such work has, however, largely focused on the family home, museums, education and social care settings with little attention paid to design around diverse cultural community heritage.

As part of a design-led inquiry into digital-material ways of making within community, we present an interactive artefact, the photo-parshiya, (digital photo-album). As part of long-term research with an international women’s centre in the UK, its purpose was to initiate discussion on how technology might support creative exploration of heritage across cultures and generations. Developed in collaboration with volunteers, engineers and furniture designers, the artefact was installed in the centre over four months and integrated into a series of workshops and public events. We highlight how particular digital-material combinations and a broader appreciation of archives to support material ‘herstories’, confidence and play with technology while drawing attention to the challenges of maintaining community, familial continuity and relevance with young people when moving to the UK.

The Photo-parshiya

The photo-parshiya is a digital photo-album designed for groups to add, store, curate and share their experiences.
The Photo-parshiyas

THEME: ENHANCING THE OBJECT

Project Timeline

The project took place between January 2013 and February 2014 and developed as an exploration of digital community archives where files are traditionally stored on computers and servers. The photo-parshiyas engineers and furniture makers between May and August 2013. A deployment of four months took place between September and December 2013, with final evaluations and follow-up interviews in January and February 2014. This extended period of design and use encouraged discussion on different processes of making between material culture, digital and non-tangible heritage, while recognising the range of skills, abilities and interests of members of the community.

Centre ‘Herstory’

The centre, where our research took place, is a charity based in the north of England, UK informed by strong commitments to social justice. The centre was established in 1993 when a collective of women activists and social workers came together to campaign for greater support and equality for women from black, Asian, minority ethnic and refugee communities within the city. A small team of full and part-time staff, including support workers, counselors, trainers, facilitators and volunteers, who are now involved with the day-to-day running of the centre, support over 150 women with access to welfare and training each year. As part of a well-established network of first, second and third generation families that migrated to the area primarily from Pakistan and India to find work in the early 60s, the centre also supports families as part of more recent migrations from Nigeria, Congo, Iran, Iraq and Syria. Those involved are politically and socially active organising protests to raise awareness of discrimination and global politics alongside events such as celebrations of achievements, religious festivals, youth enrichment programmes and elders’ social groups. Befriending schemes for those who can experience extreme isolation when adapting to different cultural values and building new social support networks when first coming to the UK, also run alongside informal peer mentoring, access to training, personal development, counseling and legal advice for immigration and intimate partner violence.

When we met with staff and volunteers in 2011, they were keen to create a legacy of their work and encourage the next generation of women to celebrate contributions from women within the local area. After a series of video-making workshops, we began to explore and speculate on what a community digital archive might look and feel like.

Design Workshops

We organised a series of drop-in weekly sessions between January and April 2013 to promote dialogue around heritage, archives and display. This included a series of cultural probes to introduce ourselves to volunteers and the wider community, and we invited women to bring objects from home. We asked individuals to share how the objects had become part of their home, and how they were stored and displayed. In addition, a visit to a design collection in a museum was arranged where objects could be handled and different processes of making with materials were discussed with professional designers and curators. Each volunteer documented the process in sketchbooks and produced design sheets, which were framed and displayed in the centre to share with the wider community.

Insights from these workshops were discussed with staff and volunteers, highlighting the importance of the sketchbooks for adding and developing ideas between home and the centre. There was further interest in creating small portable objects of decoration and adornment for the centre, home, for the self and family in the UK. The group discussed how they felt small portable objects could act as reminders to share particular experiences, for instance of particular rituals around drinking tea with...
the family in Iran or for particular ways of decorating cutlery in some communities in northern Nigeria. There were discussions between visitors and staff who showed a keen interest in the design sheets framed and displayed in the centre. Staff and visitors engaged volunteers in discussions about their ideas, shared in the design sheets and volunteers described how these conversations gave them a sense of pride in finding others were interested in the work that they had produced.

Developing the Artefact
From May 2013, we began to work with programmers and engineers on a series of designs. After developing a number of concepts and discussing these with volunteers and staff, we focused on the idea of a photo-album and the emphasis on curation and sharing as a form of storage that could be made meaningful through selection. We were mindful of wanting to create something that had a familiar reference for different members of the community, but could also be experienced as something novel and that could potentially draw interest. We offered alternative starting points for conversations as described by Gaver et al. (2011). In responding to the rich material interactions observed with objects brought from home and the sense of pride that volunteers had previously discussed, we wanted to ensure the object had a sense of occasion, but would also not dominate any space where it was installed and could be moved around in different spaces at the centre.

In drawing inspiration from Wallace et al. (2013) and White et al. (2013), we used materials that we hoped would resonate within the community but also provide points for discussion. For instance, in working with furniture designers Raskl!, they shared a number of techniques for working with wood, discussing particular provenance, the qualities of wood and how embedding the technology might effect interaction through weight and feel. From this we chose to work with Sapale wood, from West Africa, Dutch Hollandaise fabrics, Indian silks, cottons and beads. These choices were also guided by discussions with staff and volunteers to ideas of connecting the artefact to specific materials associated with global trade, design and post-colonial histories. Small wooden laser cut wooden frames were also created to house the wireless electronics to connect to the photo-parshiya to support more intimate and tangible ways for volunteers to connect to the album to contribute to both a group and personal collection of photographs.

We gave the device a name, so we could give the object a sense of being a thing in the world and chose a word that would not be immediately familiar in any language so as not to create a sense of recognition for some and not for others. Drawing from the etymology of the word participation we found the word parshiya, derived from a language that no longer existed from travelling communities in the Middle East. Staff and volunteers felt this name was suitable because of its international connections and its associations with participation within a collective.

Making Necklaces
The photo-parshiya was installed in the centre between September and December 2013 in the Aunties’ room. It was initially pre-loaded with photographs from previous design workshops. This was to test designs for the necklaces for both volunteers and staff and to start informal use in heritage sessions. A group of six volunteers, who were interested in curating and using the photo-parshiya with their own collections of photographs, were recruited in November. As a way of getting to know each other and to create their own unique necklaces to start creating their collections, volunteers worked together using small wooden frames and the wireless technology that connected to the book. Each had varying degrees of skill and confidence in making a piece of jewelry with some facilitation. However, those who were more experienced at making also helped others. In supporting one another, this often led to laughter, posing and lots of giddy photo-taking of each other once the necklaces were complete. Young children were also involved in some of these sessions creating necklaces for themselves and other family members as gifts, as their mothers discussed where the fabrics and patterns were from and their cultural associations.

In one of the group discussions, volunteer Jules described how she used a lot of social media to share her photographs with family in the Congo. At the same time she also used her own family photo-album every month to show her daughters their ancestors; grandparents, parents, aunts and uncles. Thus, her children did not forget the people that had been important for her in her own life. In this way she discussed how the photo-parshiya would be:

[A] nice way to store like all your old pictures and talk about it. Sometimes you want to share your childhood memories with your children.

At the same time she also enjoyed more playful use:

[T]o show off – oh yeah (giggles). I’m so technical you know, I’m so modern (giggles). I’d just show off yeah, so I would do that, but you can wear it as well and it goes well with any dress (laughs).

Uploading and Sharing Photographs
Once volunteers had made their own necklaces they also took part in photography workshops to add their own photographs and make their own collections. A total of 128 photographs were uploaded between November and December, with each volunteer uploading between 8-42 photographs during that time. Photographs taken by volunteers, included walks in the local area, family events, home life, cultural objects in the home, trips and events at the centre, craft objects they had made and activities within the workshop. The
collections also included photographs downloaded from the internet that included scenic places associated with countries of birth, political events, family businesses, rituals (such as marriage ceremonies and dance) and objects that volunteers were unable to bring with them when they came to the UK.

While some volunteers were initially reticent at using the photo-album, they began taking more and more photographs to share as their confidence grew. Nilah, one of the volunteers, described how she was ‘crazy about taking photographs’ and wanted to upload as many as she could. A support worker, Lilly, sat with her to show her how, and when she flicked her photographs into the album, she shrieked ‘Oooh, Look! No tension. I can pass this to my neighbour’, and started to laugh as she leaned in to transfer the rest of her photographs. At the same time she described how she was also sometimes confused with how to interact with the album:

(I am very confused because when we put it (necklace) in my hand, all the pictures come on this side (points to the right screen) so I am very confused. So why is it not open automatically?

When discussing its future potential use with Nilah, she described how she would want to use it to display her photographs so that ‘everybody [will] come to see my work, and appreciate me (laughs); feeling she had ‘improved my confidence [using] the digital things all together.’) 

**Exploring Ideas: Imagining intergenerational sharing**

The photo-parshiya was also used more directly to facilitate discussion in workshops to scope out aspects of a longer-term community heritage project. The project coordinator, Rosalyn, used the artefact in sessions to show new volunteers an alternative example of technology that had been designed within the centre. She highlighted how potential materials, such as fabrics, could be connected to digital content and encouraged the group to imagine alternative ways that young people might interact with objects creating links for sharing heritage. She highlighted how connecting specific objects with videos, audio files or layers of history could show where something had come from, showing particular aspects of global history, politics, colonialism and trade.

Volunteers, who were also part of the heritage group, also discussed how individually they struggled to keep together digital photos on a plethora of personal devices and the amount of moving to different locations they had had to do over the past few years due to uncertain immigration status. Many of those with children were also concerned with how they could pass digital and non-digital heritage, such as maternal knowledge, skills and memories, to their children in order to give them a sense of their own childhoods from their countries of birth. Others were more interested in how technology could encourage their children to have a wider global perspective that would include international women’s stories and politics.

**Informal Conversations, Distractions and Recollections**

Throughout its deployment we regularly observed the photo-parshiya being used by children and parents waiting for staff and friends in the Aunties’ room. On several occasions, before leaving the centre, our main researcher frequently met a group of three young teenagers playing with the photo-parshiya in the late afternoon after school. Some of the photographs that had been installed by volunteers were of trips that the teenagers had also been part of and they chatted about where the photographs had been taken and where and what they were doing on those days. Later on, staff described how the teenagers were meeting their mother who was struggling with mental health problems and had left their father. These meetings at the centre were the only arranged contact times she had with her children, and staff described how she often found them difficult. Staff described how they felt that the photo-parshiya had sometimes helped to alleviate the tensions associated with these meetings and encouraged the children to connect with their mother by showing her what they had been doing at the weekend.

An elder group of Aunties who came to the centre once a week did not use the photo-parshiya, but did get involved in a wider discussion about photographic collections. They brought their own photo-albums to share with each other and volunteers in response to wider discussions about community archives. The Aunties appeared less interested in looking at and using the photo-parshiya than in showing everyone that they had many photo-albums documenting their time together over the past twenty years. Izzy, one of the volunteers photographed the group with their albums next to the photo-parshiya. The following week, one of the Aunties group, who is now in her 80s, also brought in a series of photographs of her own life story. The photos included first images of her move to the UK at age 18 and of her working in her own fabric businesses, rituals (such as marriage ceremonies and dance) and objects that volunteers were unable to bring with them when they came to the UK.
store. This prompted discussions for many of the staff and volunteers about their own experiences of coming to the UK and many of them did not know that this elder Auntie had owned a store in the local area, where she imported fabrics from India.

Engaging Wider Publics

The photo-parshiya was also displayed at four social and public events in December 2013 and January 2014, involving community engagement with university partners and funders. At a Christmas celebration, as part of the centre’s heritage project, the photo-parshiya became part of the event. Young people gathered around the tables where it was displayed, and volunteers arranged their necklaces and sketchbooks on tables talking about what they had been working on. Young people, from toddlers to teenagers, tried on and played with the brooches and necklaces, interacting with the photo-parshiya to open and close the lockets on the screens. They soon became bored with this and wanted to do more with the tablets, exploring how they could play games, but continued to wear and show-off their jewelry to each other and their mothers during the party. Volunteers were photographed with the artefact, showing other guests how it worked and the photographs they had taken. Board members and staff from the centre commented how surprised at how confidently individuals talked about and used the technology to show their photographs. More importantly, they were surprised how clearly the process was described so they too could understand how the photo-parshiya worked. Lilly, a support worker, also showed friends how it worked and how it had been made by women with wood from central Africa, where they had been born. Her friends commented on how surprised they were that women could make such things that were technical and so beautiful at the same time.

Reflections on the Process

As with many social care and learning communities, long-term international migration has informed creative cultural and digital programmes that support sharing of particular heritage practices. Our approach was to design an artefact to support exploration rather than categorise and fix our own interpretations of heritage within the community and therefore sought to develop an artefact and creative strategies to achieve this. We asked how technology might support diverse forms of engagement with heritage across cultures and generations. Our current understanding is that the artefact served to inspire imagination and connection to generate ideas for the future development of community heritage practices for ongoing projects at the centre by encouraging appreciation. Appreciation for archives as having a physical, digital and visual presence within a place, which encouraged both collective and intimate appreciation of ongoing contributions from members.

At the same time, the artefact also surfaced matters of concern for the community (DiSalvo et al., 2013) around the desire to share understanding both digitally and meaningfully, not just with members, but also with family working towards both collective and personal legacies. We describe these commitments in terms of, finding an appreciation of material ‘herstories’, creating confidence and play with technology, while drawing attention to the challenges of maintaining community, family continuity and relevance with young people when moving to the UK.

Material ‘Herstories’

The particular materials chosen as part of the photo-parshiya and the associated necklaces created conversations, ideas and further inspiration within the wider community. These were used within heritage workshops to directly suggest potential points of resonance between materials, fabrics and patterns and their particular political histories. Such use encouraged staff to discuss with volunteers the potential of incorporating these ideas into future technology designs, specifically for the purposes of connecting with their children for a much longer-term heritage project. This highlighted how different forms of heritage might be further connected across digital and material making between the centre and home.

In this sense, developing an artefact that responded to the particularity of the community, and opportunities for engaged participation moved between past, present and future (McCarthy & Wright, 2004; Wright & McCarthy, 2010; Suchman, 2007). Through combining digital and material making, artefacts moved between multiple community spaces, engaging different members in conversation not just about its use, but also how it enabled group reflection on future possibilities. The necklaces were a good example, where Juls and her daughter, for instance, both made one and had photographs taken wearing them. These photographs then circulated between digital sharing on the photo-parshiya, and to create further connections with the materials. Combining the digital and material aspects provided opportunities for further conversations between young people and mothers, many of whom were concerned about how to pass on their own sense of familial heritage and share this in meaningful ways with their children.

These perspectives suggest more material-discursive relationships with the multiple things that were made during workshops (Suchman, 2014). In reflecting on the political and cultural aspects of the materials in heritage workshops, we found staff pointed to the alternative ways in which personal, emotional and sensorial connections with artefacts, as discussed by (Petrelli & Whittaker, 2012; Wallace et al. 2012; Wallace et al. 2013; White et al. 2013), might be further explored to raise matters of political and historical concern also important to specific diaspora communities (Bjorgvinsson et al., 2010; DiSalvo et al., 2013; Flinn, 2010). These findings suggest ways of re-imaging community digital heritage as connecting to broader political and affective,
personal and collective interests in the development of skills, learning and confidence in relation to digital-material technology beyond the use of artefacts.

Confidence and Play with Technology
In community based design, DiSalvo et al. (2013) describe the importance of workshops and digital artefacts in terms of confidence building, of technological fluency, criticality and creativity, which can be highly valuable for communities involved in re-imagining a future with technology. Volunteers, such as Nilah, also described growing confidence in using technology at the centre in relation to the multiplicity of ways in which different combinations, of digital and material objects, were brought together. While sometimes she expressed confusion when using the artefact and the necklace, she also described feeling supported to try it out, and how she felt excited and confident in sharing this new learning with others.

Jules, however, shared a more playful confidence in relation to the technology when creating photographs of herself within the sessions, directly through the creation and wearing of the necklaces and the performances that ensued while posing to have photographs taken. As described by Jules, ‘showing off’ in relation to the device and the necklace was also an approach to performing being ‘technical’ of being ‘modern’ around the photo-parshiya as a source of fun and enjoyment. In the context of the wider group of volunteers, the various public showings around the photo-parshiya, how it worked and the photographs on it, highlighted a desire for sharing what had been learnt and achieved throughout the project. This active engagement, through discussions with board members, managers, funders and other members of the community, highlighted the significance of performing what was known and felt to particular others within the community. Nilah described how she felt this was important as part of feeling appreciated and such sharing offered further opportunities to have the learning and work that she had taken part in valued by others. In this sense, multiple kinds of confidences were explored in relation to what was felt to be important for the individual.

Challenges of Maintaining Community and Family Continuity
With the exploratory nature of the research we encouraged individuals to decide for themselves what they wanted to photograph and present, although we suggested they think about objects, people, places and life experiences that were important. While photographs of objects associated with religious artefacts, cultural festivals and family were anticipated, we were also surprised that engagement events at the centre were also being photographed, stored and then presented back onto the photo-album. Indeed, our conversations with the elders Aunties group highlighted the importance of the longitudinal documentation of their own trips and visits as told through the introduction of their own non-digital photo album in providing a narrative of continuity of their long-term engagement and commitment to each other and the values of the centre.

In this sense volunteers, such as Nilah, created a narrative of continuity for her own and others engagement with the centre. At the same time, in being stored on the photo-album within the Aunties’ room, in an area that was also often used as a waiting or meeting space, young people who had also attended these trips could also access them. In the example we presented, this sometimes provided opportunities for young people to use these photographs to discuss their experiences with others, but also connect with family members who were distressed and upset, helping to alleviate tension and provide alternative topics of conversation.

This highlighted interesting opportunities in negotiating between personal and collective living heritage within community-based design. Heritage, for instance, was often described in association with personal experiences of migration and settling within a new country and the management of multiple mobile digital devices and physical photos as an important point of connection between mothers and children. At the same time, there was also a perceived value in making available for a wider community, photographs that would usually be kept personally, such as those taken on a group day out. This suggests a slightly different relationship to heritage and legacy than articulated by families who already have a wealth of existing material to manage (Gulotta et al., 2013; Nunes et al., 2009; Odom et al., 2012; Petrelli & Whittaker, 2012).

Conclusion
Our aim was to purposively remain exploratory, provisional and speculative in our scope. This was in order to open up lines of inquiry within the community that create opportunities for further reflections to inform future engagements with technology for heritage. Many researchers have questioned the relevance of insights that can be developed from engaging in community-based design around artefacts, especially when the very terms in which we engage in such projects are often messy, long-term, specific and situated (Carroll, 2013). We acknowledge that the approach would be difficult to directly scale up to other community-based design projects, and would therefore need sensitive and responsive consideration of the transferrable nature of such approaches. However, our study design and approach does suggest alternative ways in which community-based design research could adopt a pluralist perspective using speculative digital-material artefacts that could take account of political and affective relations to digital-material artefacts and heritage.
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Paul Dunphy is a user experience practitioner. Previously he was a research associate in the Digital Interaction Group @ Culture Lab (now Open Lab) at Newcastle University working on the SiDE project. His doctoral research was funded through a Microsoft Research PhD scholarship and he has also completed internships at the Nokia Research Centre and Microsoft Research. He is named on over 25 academic publications in the area of human-computer interaction that cover a range of topics including the design of user interfaces, usable privacy and security, and novel design methods.

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Great Expectations and Big Challenges: A FabLab as facilitator for personal fabrication of tools to self-manage diabetes

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Abstract

This article discusses the role of a FabLab as a research and making environment within the ‘Bespoke Design’ research project and its implications for the involved designers. ‘Bespoke Design’ deals with the participatory design of self-management tools for and with people with type 1 diabetes. The project furthermore explores the role of a FabLab in developing, sharing and documenting these tools. Although the context of a FabLab as an open and accessible workplace is beneficial for the idea of personal fabrication, we argue that it also poses important challenges. The necessary skills and expertise for using the different machines in a FabLab form a major challenge related to accessibility and efficiency. After all, a lack of skills and expertise can discourage people to experiment or may lead to time and cost-consuming trial-and-error. Then, if these processes become too costly and time-inefficient, one can question the relevance of developing personalised tools.

However, we believe that including a FabLab in a participatory design approach can deepen the collaboration between the designer and participant, imposing new roles for the designer (i.e. a mediator between the participant and the machinery). Furthermore, designing in this context extends this mediator-role from conceptual design to the actual making of prototypes. Based on our experiences with ‘Bespoke Design’, we elaborate on the challenges when using a FabLab as research environment and the changing role of the designer within participatory design and making projects.

Keywords: FabLab, participatory design, personal fabrication.

Introduction

FabLabs are frequently introduced as leading us towards the next Industrial Revolution, proposing big expectations in the field of making products easily and locally, thus allowing new and accessible forms of personal fabrication (Gershenfeld, 2005; Mota, 2011).

Starting from these promises, we explore the role of a FabLab within the context of ‘Bespoke Design’ (OPAK, www.designopmaat.be): a participatory design research project involving the development of self-management tools for people with type 1 diabetes.

Bespoke Design can be framed within the tradition of Participatory Design (PD): a set of theories and practices related to the concept of involving end-users as full participants in the design process. PD stimulates designing with (instead of for) people, (potentially) leading to a feeling of shared ownership of the final product (Ehn & Badham, 2002; Robertson & Simonsen, 2013).

In this line of thought, Bespoke Design aims to involve users, from the first step of the process, wherein possible design problems are explored, to the making of final prototypes. This PD approach implies that we, together with people with type 1 diabetes, explore the everyday life with diabetes and ways to self-manage this condition.

Usually, PD approaches involve this exploration within the conceptual phases of a project. However, in Bespoke Design, we extended the participatory process to the making phase; resulting in a process of participatory making or making together (Seravalli, 2012 & 2013).

To fully explore and execute this making phase, the project is carried out in FabLab Genk (BE). While the context and philosophy of a FabLab allows for extending the possibilities for participation in a design project, we learned that this is not a simple process. There are still some challenges to overcome, which we discuss further on in this paper. Currently, many healthcare projects are already being carried out within different FabLabs (e.g. 3D printing of dental implants or other medical models, etc.). However, the main difference between those projects and Bespoke Design is the bottom-up approach of the project.

Bespoke Design specifically focuses on the everyday self-management of diabetes and not on a strict medical application or perspective. In this regard, the paper starts with a concise description of essential concepts in discussing diabetes (e.g. self-care and self-management), the need for tools that fit within the
everyday life of people using them and the followed approach of PD.

Afterwards, we briefly discuss the concepts of personal fabrication and FabLabs before presenting Bespoke Design in more detail. Based on our experiences, we reflect on the idea of personal fabrication, the expectations and challenges of a FabLab for PD projects and how this affects the role of the designer. We conclude this paper by indicating some points for further research.

**Self-management Tools and Participatory Design**

Tools and technologies in the domain of healthcare are mostly designed and developed from a top-down perspective. In this approach, doctors usually define medical problems and solutions for the patients, maintaining the traditional separation between experts (i.e. doctors and designers) and laypeople (i.e. patients and users) (Storni, 2014).

The latter merely fulfills the role of a patient, experiencing some sort of health issue that can be diagnosed and for, which, ultimately, technology plays a role in his/her treatment, but without having any input in the design of that technology (Ballegaard, Hansen & Kyng, 2008).

Storni (2013, p. 54) considers this approach a ‘medical perspective that is traditionally concerned with the universalities of a disease and not with the idiosyncrasies of those affected’. However, patients possess expert knowledge on living with a chronic disease (Nøhr, Bertelsen & Kanstrup, 2009). Therefore, an alternative approach should complement this strictly medical approach in two ways.

First, it should take into account the daily needs, thus aiming for developing healthcare tools and technologies that are integrated within and personalized to the everyday life of the people using them. Second, it should approach the design of these tools and technologies from a bottom-up perspective including the patient as an expert. Ballegaard et al. (2008) propose that, when designing health tools, one should keep in mind (1) continuity in space, (2) continuity in time and (3) the aesthetic dimension.

First, continuity in space implies that the use of the tools should not be limited to a certain location (e.g. tools that are only usable in a hospital setting). It should be possible to use them wherever one wants to. Second, continuity in time illustrates the necessity that the tools should incorporate – when possible – technologies and routines that are already part of everyday life. Finally, the aesthetics of the tools should fit with the preferences of those using them (Ballegaard et al., 2008).

Starting from these ideas, Bespoke Design deals with the participatory design of self-management tools for and with people with type 1 diabetes, who use these tools for controlling and managing their condition continuously (Bauer & Ringel, 1999; Funnel & Anderson, 2004; Wootton, 2000).

Managing diabetes on a daily basis requires both self-care and self-management. Self-care relates to independent care (e.g. injecting insulin), while self-management concerns the necessary organizational framework to conduct self-care actions (e.g. making sure that you are carrying your tools with you) (Image 1).

Since diabetes is a complex condition that affects almost every aspect of daily life (i.e. nutrition, monitoring the use of medication, etc.), the general, medical oriented self-care solutions (e.g. lancet pen, glucometer, etc.) alone are not sufficient and are merely superficial answers to people’s daily wishes and needs.

While these general self-care tools aim to serve as many persons as possible, Bespoke Design aims to develop bespoke self-management tools for one person that can later be redeveloped for others. Central to the project is that the design and redesign starts from the everyday experiences of the person with diabetes. Throughout the project, three different personalised self-management tools were developed for three participants.

**Personal Fabrication and FabLabs**

For developing these tools, Bespoke Design explores the context of a FabLab and the related idea of personal fabrication. A FabLab – Fabrication (or Fabulous) Laboratory – allows people to develop and perfect a prototype of almost any imaginable product and can be defined as ‘a collection of commercially available machines and parts linked by software and processes we developed for making things’ (Gershenfeld, 2005, p.12).

In this regard, personal fabrication is the idea that we can download or develop digital product descriptions and designs and supply these to the fabricator with the raw materials to process them. This is made possible because of recent advances in ‘Open Source’ electronics and personal fabrication possibilities, such as 3D printing (Ananthnarayan, Lapinski, Siek & Eisenberg, 2014; Mikhak et al., 2002; Gershenfeld, 2005; Mota, 2011).

The idea of personal fabrication implies that we no longer have to shop for and order products, but instead fabricate them ourselves, thus creating the opportunity for mass production (Gershenfeld, 2005). Although the idea of personal fabrication and FabLabs entails many expectations and opportunities, in Bespoke Design we encountered plenty of challenges...
that we describe later on.

One of the main characteristics of the FabLab concept is sharing. Within the international network of FabLabs, every FabLab shares knowledge about its projects and designs, enabling other FabLabs to (re)produce them in a way that fits their own context, environment and available resources (Zijlstra, 2010). This is facilitated by equipping each Fablab with a common set of tools. Moreover, FabLabs operate within the context of Open Design (Mandavilli, 2006; Mikhak et al., 2002).

The principles of Open Design are derived from a development methodology known in the software industry as ‘Open Source.’ Open Design extends the philosophy of sharing, collaborating and making software public, and fosters collaborative efforts by providing a framework for freely sharing information (e.g. design documentation) (Vallance et al., 2001; Van Abel, Evers, Klaassen & Troxler, 2011). It is characterized by freely revealing information on a new design with the intention of collaborative development of a single design or a limited number of related designs for market exploitation (Balka, Raasch & Herstatt, 2009, p.2).

Relating to the idea that a product is never finished and can be reworked endlessly, the Open Design approach corresponds seamlessly with the empowerment of people with diabetes and designing bespoke self-management tools in participatory ways. Within Bespoke Design, we incorporate the philosophy of FabLabs and Open Design to document the design and making process of the self-management tools in order to stimulate others to rework them for new contexts (Schoffelen et al., 2013). In the following sections we focus on the design and development process of self-management tools for one particular participant and the challenges we encountered when using the FabLab as a research environment.

Developing Bespoke Prototypes in a FabLab: Expectations and challenges

To explore the everyday life with diabetes, the participants with type 1 diabetes mapped their experience of using self-care and self-management tools daily, together with the designers. This way, the participants provided the design team with insights in relation to the day-to-day issues encountered when dealing with diabetes.

Participatory observations (Image 2) and an interview with an endocrinologist provided further understanding; touching issues like motivation for self-care, restocking food, using tools in public, forgetting tools, etc. After this exploratory phase, designers and participants collaboratively built scenarios to tackle specific issues that were found (Schoffelen et al., 2013).

These scenarios were translated into videos and used as input for a FabLab workshop (involving other designers), resulting in the creation of three (conceptual) prototypes for three participants. In this paper, we focus on a particular development process of a series of prototypes designed for a male triathlete with type 1 diabetes. This case illustrates our reflections on the expectations and challenges of a FabLab in a PD context and the changing role of the designer.

The participant in question (the pseudonym Bill was used to maintain anonymity) wanted to wear his self-care tools (glucometer, lancet pen and insulin pump) close to his body when working or during sport. Furthermore, he indicated that the pump’s thread for the catheter was too long and impractical (Image 3).

Through different PD workshops (involving Bill and the product designer engaged in Bespoke Design) and by using the 3D printers of FabLab Genk (the Objet 30 and the MakerBot Replicator 2), two 3D printed prototypes were developed and then redeveloped.

The first prototype took on the form of a system to roll up the thread for the catheter. The other prototype entailed a clip system to attach Bill’s self-care tools to his body. The technique of 3D printing was chosen since it supports a rapid prototyping process in which a prototype can quickly go through different iterations of making, testing, re-making, re-testing and so on (i.e. a process of trial and error).

Moreover, 3D printing allows one to easily create detailed designs (in terms of resolution and finishing), which is very useful in this particular case where different types of holders for self-care tools were developed. The product designer who made the prototypes (together with Bill) had no prior knowledge of 3D printing techniques but could rely on the knowledge and experience available in the FabLab.

As shown in the table below, we will disprove, nuance or confirm common expectations and opportunities of FabLabs and the idea of personal fabrication by discussing our experiences of using the FabLab environment for this PD project. These expectations relate mostly to three main issues: accessibility of the machines, transferability among FabLabs and the cost of personal fabrication in terms of time and money.

A first series of issues are related to the accessibility of the FabLab machinery. FabLabs are often considered as innovative workplaces where one can easily make (almost) any object (Gershenfeld, 2005; Mota, 2011).
In reality, FabLabs cope with a limited amount of available machines and materials that can be used, thus restricting the potential objects that can be made. Besides, one also needs to use them and experiment with them intensely to gain thorough insights into its working and properties (Weichel, Lau, Kim, Villar & Gellersen, 2014).

The product designer for Bespoke Design had no previous experience with (designing for) 3D printing, let alone with the specific 3D printers available in FabLab Genk. However, his background in product design proved to be essential for quickly picking up the necessary skills required for designing 3D objects (e.g. using Rhino software). Many software design tools are in fact designed with expert users in mind, impeding someone who is just making the first steps into creating 3D objects, as was the case with Bill in Bespoke Design (Mellis, 2014).

Recent developments in software design tools, however, try to lower the threshold to 3D modeling by restricting the range of possible objects (e.g. chairs or furniture), although this was not applicable to the design of self-management tools in Bespoke Design (Mueller, Mohr, Guenther, Frohnhofen & Baudisch, 2014). Another issue we experienced is the fact that the technology of some software tools is not yet fully functional and/or insufficiently meets user expectations and needs. For example, when using 123D Catch to create 3D scans of Bill’s tools (glucometer, lancet pen and insulin pump), the outcome resulted merely in a 3D impression of the tools instead of an accurate, functional 3D model. As the goal of Bespoke Design was intensively involving Bill in the making process of the different prototypes (i.e. making them collaboratively), this proved to be quite cumbersome as he had no knowledge or prior experiences on using software design tools for 3D objects.

In general, 3D printing is considered a disruptive technology with endless opportunities (Calderon, Griffin & Zagal, 2014; Lipson & Kurman, 2013; Ratto & Ree, 2012). However, each 3D printer has its own properties (size and height of the printable object, layer thickness, etc.), uses a specific technology (FDM technology, polyjet technology, etc.) and type of material (photopolymers, thermoplastics, etc.) that influence the size, sustainability, strength and finishing (in terms of layer thickness and resolution) of the printed object (Hofmann, 2014; Ludwig, Stickel, Boden & Pipek, 2014). Within Bespoke Design two types of 3D printers were used, i.e. the Objet 30 and the MakerBot Replicator 2. The Object 30 printer is a polyjet printer, while the MakerBot Replicator 2 uses the Fused Deposition Modeling (FDM) technology. This means that printing the same prototype on both printers led to different results in terms of both strength and finishing.

For instance, a prototype for the above-mentioned clip system (Image 4) was first printed on the MakerBot. However, when Bill used this prototype in his daily routines, it proved to be insufficiently strong, resulting in a broken clip system. Moreover, for several prototypes we found that the wall-thickness is a crucial factor for the printed models’ fragility. Wall-thickness is largely dependent on the material used (and the imposed minimum thickness), but also on the design of the prototype, making it nearly impossible to predict the necessary thickness for different printers.

Second, the large variety of available types of 3D printers and technologies complicate sharing experiences or designs among FabLabs or beyond. FabLabs are closely related to a more general culture of openness, sharing and collaborating (see: Fab Charter – http://fab.cba.mit.edu/about/charter/). However, reality shows that little information is shared within the international network of FabLabs, since opening up the creation process and sharing it online through the use of so called ‘Fab Moments’ proves to be a considerable challenge for most FabLab users (due to lack of time or...
motivation) (Schoffelen & Huybrechts, 2013).

As we stated above, one of the underlying ideas of stimulating exchange among FabLabs is equipping them with a common set of tools. However, as we experienced in Bespoke Design, sharing the designs of the prototypes with other FabLabs does not always end in comparable results since different types of 3D printers (in terms of technology, properties and material) are used; thus limiting the opportunities for easily sharing and reworking the designs.

Furthermore, the relative novelty of the technique, the different technologies, materials and applications as well as the use of different terminologies and the general lack of expert knowledge in FabLabs hamper the use of 3D printing technology in terms of personal fabrication. There is no general open repository that collects information on the different types of printers, the materials used, the strength of the materials, etc., making it impossible for novice users to have a clear view on the end result of the prototype before printing (Ludwig et al., 2014; Mayson, 2013).

Third, the idea that 3D printing is a quick and inexpensive process needs to be nuanced. For personal fabrication, it is cost-efficient that one can make a prototype without having to produce a whole series or use expensive moulds. As we experienced in Bespoke Design, 3D printing of personalised self-management tools is time-consuming. Not only the printing times are considerably high (Mueller et al., 2014) but making these tools requires different iterations, which can strongly increase the overall costs.

For example, the clip system for Bill was remade seven times before an adequately functional and testable prototype was obtained. We mainly used the Object 30, which features a fairly high average printing cost in contrast to the cheaper and more fragile prototypes printed by the Makerbot. As a result of switching from the Makerbot to the Object 30, the total cost of printing the different prototypes (i.e. of the clip system and the system to roll up the thread (Image 5)) was higher than initially estimated.

Nonetheless, the trajectory in Bespoke Design was limited to the design and making of personalised prototypes of self-management tools. In this sense, the environment of a FabLab was a useful setting since it provided us with access to and knowledge of (in the form of assistance from the FabLab manager) the machines to iterate through different prototypes. However, transforming these prototypes into working products (produced on a larger scale) requires additional steps.

Furthermore, the specific participatory setting of Bespoke Design further increased the investment of the designer and participant (in this case, Bill) needed to develop a set of personalised self-management tools. Although, a FabLab, as an open research environment, facilitates collaborating in an informal setting, it requires an enormous engagement of the participant to continuously invest time and energy in the design and making process of a limited amount of prototypes. While this is the case for every PD project, the participation of Bill in the making process prolongs the period of time that the participant is engaged in the project.

Reflecting on the process of making self-management tools together with Bill, we found that creating individualised solutions adapted to the needs of one particular person is a long-term process that is time-consuming for both the designer and participant, which is not always feasible in an economical sense.

The final series of prototypes for Bill are being used for several months now and have proven to be sufficiently usable and firm for daily use. However the aesthetics of the prototypes, in terms of look and feel, should be further improved in order to attract and be manufactured for a larger group of potential users.

Therefore, as we experienced in the project, 3D printing is not the straightforward, easy and low-cost process that common rationale dictates. It is in fact -like most prototyping processes—a continuous case of trial and error, (re)designing and (re)testing, still requiring a lot of input from the designer.

As experienced in Bespoke Design, the willingness and motivation of Bill to intensively participate was unfortunately not enough to overcome his lack of knowledge and skills on 3D printing for him to actively participate in the making process, exposing implications and new rules for the designer.

Implications and New Roles for the Designer

The goal of this paper was to explore the idea of personal fabrication and the role of a FabLab as a research environment for PD projects. Our experiences in Bespoke Design, and more specifically with developing a series of tools for Bill, indicate that a FabLab can enable a close relation between designer, participant and machines, placing the role of the designer as a mediator for participation in a different context.

While this role is well known in the conceptual design phase (see Participatory Design), the role of the designer as mediator in making prototypes—which a FabLab allows—is relatively new. This change from participatory design to participatory making (or
First, an important element in the entire making together process is introducing the practices of prototyping to the participant. The design team, and specifically the product designer who designed the prototypes in a one-on-one relation with Bill, experienced the uncertainty that designers are often confronted with when designing in participatory ways.

PD projects are in essence always uncertain since they rely heavily on the input from other participants and therefore have an unclear or unpredictable outcome (Dreessen, Huybrechts, Laureysens, Schepers, Baciu, 2011; Huybrechts, Schepers & Dreessen, 2014). Subsequently, the design, but also the participation, is placed in an uncertain situation (Huybrechts et al., 2014). Iteratively developing prototypes further increases this uncertainty and requires the designer to explain this iterative process to the participant who is unfamiliar with these practices. Or as stated by Seravalli (2013, p. 12):

Transfering a prototyping approach to non-designers can be quite difficult since it means to accept that failures are positive occasions from which one can learn: if failure is related to a project where a lot of resources are invested and expectations come into play, it is difficult to consider it as something that should be welcomed.

Although this way of working was sometimes difficult to grasp for Bill, he stated in a final evaluation the value of gained insight in this process. Closely related to the latter, is the task of the designer to ensure a continuation of the prototyping or making the process engaging enough for the participants involved. This continuous process of trial and error requires important efforts from the designer to maintain a steady participant involvement by keeping them motivated to participate actively throughout the project.

A final task for the designer in this process of making together relates to the ownership of and giving up control over the project. PD, at its core, is about sharing ownership and releasing control by the designer over the design process (Schepers, Huybrechts & Dreessen, 2011).

As mentioned before, taking participation further into the making process increases the importance of releasing control by the designer even more and changes the relation between the designer and participant. On the one hand, this can imply a more passive role for the designer: a mediator between the participant and the machines, a problem-solving guide aiding participants when necessary. However, as we experienced, this was not the case due to the lack of knowledge on 3D printing by the participant. On the other hand, the relation between the designer and participant can become more concrete since it involves the making of tangible prototypes.

For instance, we found that during the project participants think aloud very concretely and also explore possibilities while holding or collaboratively making the tangible prototypes (e.g. asking for specific functionalities to be included in a prototype), deepening the collaboration between designer and participant.

Conclusion

Although the context of a FabLab as an open environment and the idea of personal fabrication can be very beneficial for the idea of personal fabrication, some important challenges remain. As described in this paper, the main issues we experienced in Bespoke Design can be subdivided in to three categories.

A first major obstacle relates to the accessibility of the FabLab machinery and having the necessary skills to operate them. As our experiences with Bill showed, this proved to be a major obstruction preventing him from actually making the prototypes together with the designer. Furthermore, the lack of standardization and documentation, the lack of experience in 3D printing and the use of various 3D printers, complicated the making process for everyone involved.

As stated in the second category, this lack of standardization (using the same type of machines) among FabLabs, the absence of a repository on the use of 3D printers and the lack of sharing through the system of Fab Moments, hinders easily sharing information. Furthermore, it also obstructs designers and novice users to get a clear view on the cost, material properties, look and strength of the design, resulting in an uncertain outcome with most print jobs.

The final issues relate to the common idea that 3D printing is an easy and quick process for prototyping. Due to the relatively high printing cost, the printing time and the different iterations needed to obtain a functional and testable prototype, one can question the use of this technique for developing personalised tools.

However, we believe that choosing a process of participatory making (thus including a FabLab in a PD approach) provides the designer with new roles and tasks in these kinds of design projects (i.e. a mediator between the participant and the machinery), and creates a more profound relationship between the participant and the designer.

Furthermore, designing in this context expands this mediator-role from conceptual design (exploring problems and possibilities through co-design methods) to the actual making of tangible prototypes.

We believe that developing a discourse concerning
this new mediating role of designers in participatory making, similar to the discourse of methods and tools in participatory design, can be very valuable. This paper can be seen as a small contribution to this discourse, although additional research is required.

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Laser Welding of Textiles: A creative approach to technology through a reflective craft practice

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Abstract

In an increasingly digital age of manufacture the role of the craft practitioner and particularly hand making processes has had to be reconsidered. There are those that would argue the depletion of goods made by hand simply negates the need for making skills in the development of new products; however, there is an emerging argument that places more value in the potential benefit of craft practice, and particularly making, to bridge between scientific knowledge and the needs of industry.

This paper calls upon the research of Dr. Kate Goldsworthy and Helen Paine, who have utilised laser-welding equipment to explore the benefits of a ‘craft approach’ in assisting the development of an emerging technology for decorative and functional textile finishing applications. Goldsworthy first worked with the technology in 2008 during her doctoral research, and has used it to develop unique surface finishes for textiles that preserve material purity and can be recycled within a closed-loop system. TWI, the inventors of the technology, funded Paine’s current doctoral research, and wrote the original brief for the project that is essentially technologically driven; from which Paine has chosen to investigate new aesthetic and functional opportunities for stretch textiles offered by the equipment. Despite the disparate contexts for the research of Goldsworthy and Paine, their shared background in textile design has led them both to follow a familiar practice-led approach. In this unified approach they have been able to collectively recognise the benefits of working in a hands-on way with the technology. This paper will explore techniques undertaken by both researchers during their investigations and share their insights from working with the laser welding equipment, made available to them by TWI. More widely, the paper will demonstrate the benefit of an intuitive craft approach in the development of an emerging technology.

Keywords: Technology, craft, textile finishing, laser welding, tacit knowledge, creative problem solving.

Introduction

Goldsworthy and Paine have both developed practice-based doctoral projects using laser technology based at The Welding Institute (TWI), in Cambridge. Goldsworthy first worked with the technology in 2008 and has used it to develop unique surface finishes for textiles that preserve material purity and can be recycled within a closed-loop system. The inventors of the technology, TWI, subsequently funded Paine’s current doctoral research project, which began in 2012. Paine is investigating new aesthetic and functional opportunities for stretch textiles offered by the equipment. Both doctoral projects have resulted in new IP being considered for industry exploitation.

Despite different research contexts for the technology both have a background in traditional textile design; Goldsworthy in printed textiles and Paine in knit, and have adopted practice-led approaches that reflect these specific skills and experiences.

This paper will outline their collective insights through working with laser welding during their doctoral practice, illustrated with specific examples of their experiences of developing a craft practice using a digitally driven and lab-based technology. In particular, their approaches to overcoming the manifold barriers created by the nature of the process are explored and discussed in order to demonstrate the benefits of a craft approach in the development of such emerging technologies.

A Brief History of Laser Welding Technology

(Transmission Laser welding)

Laser welding of textiles was first developed at TWI during the mid 1990s. The process was first demonstrated to join plastic materials and could only be applied, before TWI’s developments, to join materials of a dissimilar colour. The nature of the process relies on the transmittance of the laser through the top material and the absorbance of the laser in a lower material. Dyes in the materials have a direct effect on the transmittance of the laser and TWI developed a laser absorbing dye, which could be placed at the interface of the materials to be joined. This made joining materials of the same colour possible for the first time. TWI has successfully demonstrated feasibility for the technology to be used in various seaming applications as varied as clothing, furniture, medical devices and airships. Seams, in some cases, have exceeded strengths achieved using traditional stitched seam methods. Other benefits
offered by the technology over alternative methods include increased manufacturing speed, an ability to produce waterproof seams in a one-step process and an almost invisible appearance on the outer surface of the material.

**New Applications of the Technology Developed by Goldsworthy and Paine**

Goldsworthy’s doctoral project (2005–2012) first demonstrated potential for new applications of transmission laser welding for textile finishing and creation of composite fabrics by using it as a tool to transform polyester fabrics into varied and complex designs that were monomaterial in composition to enable repeat recycling within a closed loop system. Material limitations and faults in the welding process, such as melted and marked surfaces, that are considered undesirable for welding in other applications, were employed to useful effect in creating these varied decorative finishing techniques.

Helen joined TWI in 2012 to undertake a PhD project to further develop an understanding and capability for this advanced method of joining textiles. Responding to this technology driven brief she chose to take a practice-led approach in pursuit of new opportunities. There was an interest in exploring the aesthetic opportunities enabled by the technology and the research has centred on the development of seaming and surfacing techniques for stretchy fabrics.

Coming from a background in textile design both researchers have developed a familiarity, and preference for, a hands-on and intuitive way of working that is combined with a methodical research approach. Their understanding of the technology has been developed largely by taking a playful and intuitive approach of trial and error; to first gain an understanding of the technology and overcome an imposed remoteness from the tools of making. The challenge facing makers exploring production processes that rely wholly on CAD/CAM is described by Philpott (2010) as a ‘removal of the intimacy of touch from the design process’.

**Physical Barriers Between Maker & Machine**

This first set of challenges relates to the physical set up of the technology and overcoming an imposed remoteness from the tools of making. The challenge facing makers exploring production processes that rely wholly on CAD/CAM is described by Philpott (2010) as a ‘removal of the intimacy of touch from the design process’.

**Barrier: Remoteness from process**

Due to the nature of the process it is necessary for the equipment to be set up in a separate and sealed environment to which the operator can only gain access when the laser is turned off. The computer control workstation is located outside of where the process is controlled and managed, meaning the user needs to view the material through a camera linked to the equipment. Whilst this interface allows the user to see if there is a problem with the equipment itself, it is not possible to see the effect on the material without stopping the machine, going into the room and removing the material from the flatbed. This results in a very broken and disjointed process which needs to constantly be stopped and started, with a certain amount of guesswork needed in order to make decisions about the settings and their effects. If the material is completely taken off the machine it would be impossible to replace it without creating a gap in the design.

‘In the making process the hand becomes intellectual, enabling the simultaneous creation and
analysis of work’ (Philpott, 2010). However, in this case the physical distance between the maker and the machine during the process causes a distancing not usually experienced during traditional hands-on processes. The usual continuous opportunity to oversee or manipulate the material during the manufacturing process is removed. It is true to say that this dependence on the presence of the maker can vary to a greater or lesser degree in traditional making methods; however, there is rarely an occasion when the maker would be completely removed from the activity of transformation to this extent.

Solution: Creating moments of pause for ‘reflection in action’
Through a cycle of trial and error with the unfamiliar set up it was discovered that by pausing the equipment during a cycle the researchers could go back into the room and make visual assessments without creating any negative effects on the material. This was not a function that the scientists in the department used during their experiments and therefore had not been originally known to be possible. Although this did not give the full detail that taking the material off the machine would have done, it did at least allow major faults or incorrect settings to be picked up through the protective barrier.

If the maker scrutinizes and assess their actions as they make this can advance the practice as they can respond rapidly to insights gained whilst making and amend their actions as necessary. (Philpott, 2013)

This solution also had a secondary benefit of creating a method for hand-marking the materials through the physical interruption of any program during its cycle.

Schon (1983) advocates that good designers should reflect upon their action both during and after practice in order to move from exploration to ‘commitment’ as they recognise the implications of each material situation. In working with the laser from outside the lab it was difficult to reflect upon the work during progress. Using the pause button did help to some extent to imitate normal working practices which were in so many ways lost working with this unfamiliar set up.

Barrier: Lack of creative space
The spaces themselves are set up very much as a scientific lab and not a design studio. This element is usually a vital part of what it means to be a maker – surrounding a space with visual elements and materials in order to analyse and review samples during the process. In practical terms, there was little surface area on which to work and lay-out design work for review during the process. This was extremely difficult in such a utility space with no surfaces to work on.

Solution: Creating a temporary studio set-up
Without the space in the lab to pin work up and reflect upon it during the creative process of making, mount boards were used by both researchers as a sort of transportable alternative. Finding ways to mock-up familiar studio environments where possible assisted in getting in to the zone for creative work.

Barrier: Removal of the hand & the ‘reveal’
This removal of the maker’s hand in the process creates a barrier to tactile understanding. The laser works its magic separate from the maker who loses the haptic feedback of working directly with materials. This creates a moment of reveal when you remove the materials off the laser once the process is complete and you see for the first time the effect that it had created.

In response to these challenges, the researchers employed various tactics in order to negate the negative impacts of the distancing between themselves and the machine (tool).

Solution: Integration of hand before and after laser processing
The removal of the hand at the point of production does not mean that there were no hand-manipulated processes at all. It was found that by manipulating the
Goldsworthy and Paine found that by stretching out fabrics using an embroidery hoop before they were processed using the laser, fabrics were set into new positions creating a three dimensional surface effect.

Goldsworthy often built up designs in layers, each responding to the previous results. By combining physical manipulation techniques such as pleating, creasing and gathering of particular layers, controllable variation of 3D effects could be achieved.

**System barriers between maker & software**

The software which runs the robotic axis of the flat-bed system also creates a language barrier between the maker and the tool. The challenge is how these input systems can be navigated and controlled most directly from design to realisation.

*Barrier: Unfamiliar ‘machine language’ driven by coding*

The unfamiliarity of the software, a *machine language* driven purely by coding, makes the usually instinctive translation of imagery and line from the hand-drawn to the digital almost impossible. Every movement of the laser head has to be programmed as coordinates, a kind of dot-to-dot process, making anything more complex than a series of repeating lines almost impossible to make. For designers used to using design driven software, such as Adobe, this is an agonising process, and completely counter-intuitive.

*What is of particular interest is the way in which artists, applied or otherwise, wisely, wilfully, tend to do low-tech things with high tech technology.*

(Harrod, 2007)

*Solution: Integration of familiar craft practices*

Both Goldsworthy and Paine relied on tacit knowledge from their own specialism (knit and print) in order to find a solution to this barrier. In particular, using mark-making methods as a way to reveal the programming directly through the laser movement. Paine attached a pen to the laser head and ran existing programs stored in its memory. This enabled the program to be seen in action and to produce a physical full-scale map of each one for reference.

A second technique involved using black photocopy paper (simply laser-printed black sheets) as a carbon copy to reveal where the laser was working by fusing the carbon from the copy onto a clean sheet and thus reveal the movement.

*Solution: Creating raster patterns through bypassing the software*

As a print designer, Goldsworthy was interested not only in the seaming or stitch-like effects that the laser could produce through vector lines, but an all over patterning or image based finish in order to replicate the desired print based finishes. In order to do this she drew on experience as a print designer and developed a stencilling process (based on traditional screen-printing methods for all-over surface effects) to mask the laser so that it only effected the desired parts of the material. The more detailed the stencil the more *photographic* the effect. This was a breakthrough in the creation of the number of finishes that could be replicated with a very simple laser-programme.

Flocking, devore, gloss-coating, and printing effects could all be replicated, as well as some more complex composite materials if the laser was used to laminate multiple layers together. This was the first time the technology had been used for anything other than seaming, and it opened up a vast array of potential manufacturing opportunities, which could be achieved without the need to change the laser programme during production.

Working with an all-over raster pattern to create surface effects in this way can be a slow process as the laser is focussed to a point that is less than 1 cm wide. This has to travel across the whole surface of the material. Goldsworthy devised a system of creating multiple samples at once that explore a variety of processing conditions and material lay-ups. By adopting a systematic and methodical approach to the technology, she was able to maximise her material investigations in a restricted time frame. Once the desired effect had been achieved, laser settings could be adjusted to prioritise the speed of production without negating the material and aesthetic results.

*Solution: Copy and pasting bits of existing programs together- hacker mentality*

Using visual methods to map out the movement of the laser, Paine found it was possible to isolate parts from existing programmes on the system and copy and paste them into new programme files. Hashing various parts
of different programmes together it was possible to build new designs without a thorough understanding of all the coding instructions. This process of borrowing elements from pre-existing patterns to build your own designs can be compared to the process of designing knitted textile patterns or collage. Working with a range of established stitch patterns new designs can be developed by combining these patterns in different sequences and varying proportions.

**Material Barriers Between Maker & Material**

Material restrictions are complex and depend on knowledge that cannot be ascertained from information often provided by retailers of textile materials. A detailed understanding of material behaviours was developed through the hands-on experience of reflective practice with the technology.

**Barrier: Understanding material limitations**

Material suitability for laser welding depends on a number of factors not usually necessary for a maker to consider. It is understood that materials must have a high level of theroplastic content so that they melt when heated. Familiar synthetic textile materials, such as polyester and nylon, can be used for the process; however, it also relies on the material being able to transmit a high proportion of the laser energy. This material property is unlikely to be known even by the manufacturers as it is only relevant for this particular technology. Mostly, all coloured synthetic materials are suitable; however, some additives such as colourants and binders that may not be listed by the manufacturers can be problematic to the process causing unpredictable results that mark the top surface of the material or create undesired effects. Any new materials need to be first tested for suitability before being used even if fibre content is known. The construction, colour, finish and hidden additional materials may also effect its response to the process.

**Solution: Using restrictions as an opportunity**

For laser welding the top material must be transparent to the laser so that the energy can pass through and form the weld at the material interface. Working from an intuitive craft approach, exploring new visual opportunities for the technology, these material restrictions could sometimes create unplanned surface changes which it might be possible for a designer to exploit to useful effect.

Designers are often seen playing around with ideas, tossing up possibilities (proposals) in what may look like a hit and miss process. What they are in fact doing is trying out and thinking through many possibilities, thus building up a repertoire of experiences that help them develop an intuition of what will work in the problematic situation. (Dorst, 2010, p.133)

At TWI, Paine was shown how to test the transparency of a material to the laser using an energy meter. A 2 J pulse of laser energy is passed through the material and then re-measured on the underside to see how much energy has been absorbed. Any material that absorbs more than 80% of the laser energy will not be suitable for using as the top surface in laser welding. Using this scientific method Paine was able to develop further insight into how transparent a particular material was to the laser. However, in a quest to explore alternative decorative mark-making opportunities the researchers played about with material configuration, exploring the effect of different material lay-ups on the visual quality of the weld. As the investigations in the beginning were not concerned with weld strength there was freedom to explore the visual impact of material lay up without considering the strength of the weld.

**Barrier: Process depends heavily on machine parameters and not factors that are controllable by memory through the hand**

The laser welding process is controlled by a number of variables that have to be programmed into the machine. Repetition of effects depends on the...
interrelationship between these variables. Once a new technique has been developed the process, including machine parameters has to be fully documented if effects are to be repeated. Work produced by textile designers, although likely to be dependant on hand-manipulated processes that cannot be recorded in the same way. Effects are repeated by applying the memory of how they were achieved before. This process is not concerned with remembering specific numerical settings, but more about finding a familiar feeling through the hand, which is cast in the memory of the maker from previous experience.

**Solution: Adapting record-keeping methods**

Pre-preparing methods for recording brought a more systematic framework to the process of making, that was rigorous yet minimally invasive to the intuitive craft approach. This rigorous recording of the making process can disturb the intuitive craft practice through repeated breaks. The intuitive process of making can seem oppositional to the rigorous scientific methods of record keeping required for laser welding. It was therefore necessary to devise techniques for recording that minimised disruption that might disturb creative trains of thought.

With the aim of keeping track of the parameters and processes that were linked to different effects, sketchbooks became more like technical journals. Spec-sheets were pre-prepared ahead of making with spaces for all the relevant variables to be recorded. As each sample was produced it was attached to the relevant spec sheet and immediately stored in a file. Photographs were also used as a way of documenting any parts of the process that were particularly unique or vital to a particular effect. It also became increasingly important to date any work in sketchbooks or notebooks so that textural and photographic records could be connected and reflected upon together retrospectively.

> *The representations of problems and solutions (in words and sketches, sometimes using quite sophisticated visualisation techniques) is important because it allows the designer to develop their ideas in conversation with their representation.* (Dorst, 2010, p.133)

The act of methodically recording results and parameters became part of the creative process and allowed reflection to continue before and after continued experimentation.

**Conclusion / Insights**

Following the analysis of the examples presented in this paper there were several points considered as useful for further investigation and consideration. Insights from the combined experience of Goldsworthy and Paine in their approach to the technology is summarised below.

- Cheating the technology: Using tacit knowledge from their embedded print and knit craft knowledge in order to find ways to control the system in order to achieve desired results.
- Understanding material behaviour: It is not possible to choose materials for aesthetic and tactile properties alone when using such transformative technologies. The behaviour of fibres under the conditions of the process become the leading feature of the selection process.
- Creating moments of reflection: Digital technologies are not often designed with experimentation of process in mind. Designers need to find ways to get closer to the process in action in order to reflect and evolve their practice.
- Embracing new tools and scientific methods: Often new skills borrowed from a scientific field become essential to deepening understanding and developing a new techno-craft approach.
- Developing ways to record and analyse results before, during and after processing: Complex processing parameters including technical, material and craft methods need to be carefully recorded in order to make results repeatable and transferable.

When working with such an unfamiliar production technology, both textile makers used these tactics to control the process and ultimately find new techniques and applications that continue to develop through their current practice.
References


Kate Goldsworthy is senior research fellow at the University of the Arts London in Textiles Environment Design (TED) at Chelsea and a lead researcher with the Textile Futures Research Centre (TFRC). With almost 20 years of experience as a textile designer, consultant and academic, her core interests are design for cyclability, new finishing and production technologies and material innovation.

Helen Paine is a Doctoral student funded by TWI and based at the Royal College of Art London. Coming from a background in textile design her research has followed a practice-led approach working closely with industry to seek new functional and aesthetic opportunities for existing advanced joining technologies.
Interfacing Design and Making of Ceramics: Expansion of ceramics practice through technology

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Introduction
Following Senneth (2008), technology often seems to take us away from the material. The need to create representations prior to the engagement with material, as when we engage with 3D printing of ceramic material, prohibits appraised methods of making, which is considered key to craft and artistic practice. These practices are based on the idea that direct physical and tactile interaction with a responding material guides the ceramicist (Leach, 1940, Dormer, 1994), and crafting and execution works as a unity that is intuitive and humanistic (Leach, 1940).

Rather than thinking in diametric positions, this research proposes to see technology as an enabling force and follow McCullough’s (1998) idea about a close connection between digital work and craft practice. Focusing on practices with ceramics, we pose the question: how and where can traditional craft based knowledge, routed in skills and experience of making three dimensional objects, be implemented in novel ceramic processes, which utilize digital technologies?

Following Leach and Dormer, we argue that traditional craft can be understood through two parallel levels: its immediate interface to matter, which is able to provide instant feedback, and through the consistency of design logic and material process.

Novel digital approaches create new interfaces and processes between human, space and material. Advances in 3D motion capture technology and sensors allow us to capture spatial hand gestures and body movement in real-time. At the same time, digital technology such as 3D printing with ceramics, allows us to create a bridge between the digital design environment and fabrication.

This research investigates how these technological developments open spaces for new expressions and allow rethinking of traditions in ceramics, while enabling the designer’s body to be involved in the making once again.

On the Properties of Materiality in 3D Ceramic Printing – As the dominant amount of 3D printing approaches focuses on the materialization of arbitrary shapes, material is often sidestepped. In a two-step process, the digital representation of a designed shape is first sliced. A second step introduces support material in places of the shape that defy gravity. While current research focuses on minimizing this support, using for instance built simulation processes (Schmidt, 2014), one can consider this as post processing of an approach that is
at its core agnostic to questions of matter. It removes the materiality from the printed part.

In this frame of the project, we understand materiality in an extended way. Firstly, being the result of the interaction of the designer with the responding matter (in this case clay) and secondly, the process (3D printing, firing and glazing). Our approach aims to include the knowledge of materiality into a holistic approach.

This takes place on the level of material processing through the creation of a bespoke design and fabrication process that is built upon the very genesis of shape in 3D printing with clay: the extrusion of a line of material. This thinking, in a continuous path, is finally the point of departure for our design and making.

**Method**

Design in our research project, is used as a method of inquiry, or a reflective practice in which the designer engages in a dual mode of reflecting on action and through action (Schön, 1993). Moving between the exterior and the interior of making, design creates a conversation between the dispositive action of analysis and critical assessment, and the creative action of proposition and result.

A series of parallel and interdependent introductory experiments with digital technology and ceramic material formed the starting point in this research. The experiments acted as inquiries by which the concepts, technologies and material were tested and evaluated within a wide frame of possibilities that reflected the overall research questions in a very general way: what is possible and how? The introductory experiments gave rise to new questions and experiments. At the same time these helped to focus the research as they established a growing framework that helped to evaluate and verify the results as the experiments grew larger and larger in scale over time.

The final experiments should, nevertheless, not be seen as final results, but as representative examples of experimentation that reflect the dynamic and unique possibilities in the cross border between digital and ceramic crafting.

**Experiment**

The experiments were situated in a context that allowed the combination of specialized knowledge of ceramic material, and architecture with digital technology in an interdisciplinary platform. Our design ambition was to enter the architectural realm with ceramic material, and architecture with digital technologies and material were tested and evaluated within a wide frame of possibilities that reflected the overall research questions in a very general way: what is possible and how? The introductory experiments gave rise to new questions and experiments. At the same time these helped to focus the research as they established a growing framework that helped to evaluate and verify the results as the experiments grew larger and larger in scale over time.

The final experiments should, nevertheless, not be seen as final results, but as representative examples of experimentation that reflect the dynamic and unique possibilities in the cross border between digital and ceramic crafting.

The process of our early experimentation resulted in a sketch of the concept for a computational system for designing wall-like compositions based on modules in ceramics that modulate light. This computational system negotiates between the design intent, expressed in the interactive movement of the designer’s hands, the 3D clay printing process and the following steps, such as firing and glazing, which further influence the shape and appearance of the product.

**Preliminary Experiments: Material and technology**

The creation of an environment that is able to hold the whole process, from capturing the designer’s hand movement to 3D printing, is a complex endeavor, which we did not want to further confuse through a heterogeneous development environment. The 3D modelling software, Rhinoceros (Robert McNeel & Associates) and its graphical programming interface, Grasshopper (developed by David Rutten) provided a single software that could satisfy all needs. It is possible to interface a Kinect developed for the video game console Xbox (http://www.xbox.com/en-US/Kinect) for

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**Image 1.**
The Kinect captures the designer’s hands movement, which is inputted to the computational system that was developed in the plugin, Grasshopper, for the 3D modelling software, Rhino.

**Image 2.**
The RapMan utilized for 3D printing with clay.
capturing the movement of hands on the one side (see image 1), and interface the RapMan 3D printer (http://www.rap-man.com.au/), on the other.

The project utilizes the RapMan for 3D printing in clay, a technique developed by the Belgian design duo UnFold (http://unfold.be/), and introduced into our context by the ceramic artist Jonathan Keep (http://www.keep-art.co.uk/) (see image 2).

The Physical and Parametric Module
The modules of the wall like composition are based on the material process of the RapMan printer: they follow the logic of a continuous coil, which allows the printer to build all its layers in a module without pause (see image 3). The pattern generated in the computational tool follows the principle of a continuous curve (see image 4).

A continuous process of iterations of physical prototypes with the RapMan printer and the careful registration of the results allowed us to tightly link the behavior of the ceramic material to the development of the parametric module.

The prototyping provided us with an understanding for the need for internal support of the walls. We observed that modules with straight, unsupported walls deform easily. This led to the invention of inner stabilizing patterns for the modules. These structural needs provided a rich ground to include further functions as ornament and light filter (see image 5).

Prototypes also led to an understanding of maxima and minima, which resulted from the interplay of technology and material. The maximum sizes and height of the modules and the shift of layers were, for instance, simultaneously defined by the RapMan dimensions as the shrinkage of the material.

The undulating curve carries all the information needed for the printing. It constitutes both the outer boundary of the module and the inner supporting patterns. The inner pattern can be modulated between a pattern of straight lines and curves, for both aesthetical and light performance.

The amount of empirical knowledge gained through prototyping (the sheer amount of possible combinations of parameters), necessitated a classification into two types of parameters:

1. Interdependent parameters, which are directly related to another parameter and cannot be user controlled.
2. User controlled parameters, which can be controlled, but is at the same time depended on or are constrained by other parameters through simple formulas derived from empirical studies of the printing and material behavior.

The verification in further iterations resulted in a parameter space that allowed to define the single, as well as the composition of many:

1. Module position: User controlled. Not depending on any internal or external parameters. Positions the module in 3D space.
3. Height of the module: User controlled. Constrained by the RapMan printer and material. Specifies the amount of layers for the continuous curve.
4. Amount of supporting inner patterns: Interdependent. Depended on the radius of the...
module. Changes the amount of meeting points between inner pattern and outer rim of module.

5. Radius of the inner hole of the module: User controlled. Depended on the radius of the module. Changes the radius of where the inner pattern ends towards the middle of the component.

6. Curvature of the inner pattern: User controlled. Constrained by the behavior of the material. Changes the curvature of the inner pattern.

7. Shift/twist of layers: User controlled. Constrained by the material behavior, depended on the radius of the module. Rotates each layer by a certain degree.

8. Shrinkage: Depended on the material, firing and glazing. Scales the printing curve up so module, after shrinkage, fits drawn size.

This parameter space can be directly accessed and controlled by the user through number sliders or through the interface of the interactive system, while the inbuilt computational rules make sure that the constraints from the printing process or the material behavior are maintained.

The resulting continues curve is subsequently translated through a custom python script into G-code, which is readable by the printer. After printing in porcelain the modules are glazed and fired to 1280 degrees.

The Interactive System

While the parametric system holds the knowledge about the process and the design of a single module, an interactive system is set up to interface with the overall composition of the modules. The system consists of a Microsoft Kinect, which is interfaced to Grasshopper (Firefly) (http://www.fireflyexperiments.com). The Kinect captures a point cloud from which the position and movements of the hands can be extracted and utilized as parameters for the parametric modules.

The movement of the designer’s hands is recorded and transformed into a trace of cylindrical modules by the computational system. Through the interaction, the size and pattern of the module emerge and change in real time in smooth steps according to the movement of the hands (see image 6). Over time, each module changes pattern and reduces its size and it disappears or can be manipulated by new interventions. Finally, a trace of modules can be captured (see image 7).

The point of departure for the overall composition of the circular modules is that these want to be packed as densely as possible. This physical behavior can be resembled in computation through a circle-packing algorithm (initially a C# script by Daniel Piker, later to become MeshMachine). Our script uses a dynamic approach to circle packing, where the variation of the sizes of circles depends on the relative spatial position of the hand of the user over time. The hand of the user can be traced, and modules can be laid out according to his movements. Our experiments resulted in a framework that guides the interaction: the process...
starts when the hand enters a specified physical volume in front of the user. The sizes of the modules depend on the speed of the movement in xy coordinates according to the drawing plane. The faster the hand is moving, the larger the module will become.

We interfaced furthermore internal parameters of the parametric module to the movements of the hands: the movement in the z-coordinate to the drawing plane of the separate left/right hand. Image 8 shows the basic schematics.

1. If the user moves their left hand in the z direction the inner pattern will change from A to B to C (see image 8). Thus, the inner pattern will gradient from straight to curved.
2. If the user moves their right hand in the z direction, the inner pattern will change from A to D to G (see image 8). Thus, the radius of the inner hole will change.
3. Or the change can be defined by a combination of 1 and 2, as a change from A to E to I.

Continuous experimentation provided insights, which of the parameters for the modules, could be linked to the designer’s movement that would provide them with meaningful control and feedback from the interactive system:

1. Module position: Modules are laid out according to a distance threshold from the xy-position to the drawing plane of a hand within a specified volume.
2. The radius of the module: The speed of the movement in xy-coordinate to the drawing plane of the hand explicitly sets the radius of the modules, but this is also implicitly affected by the radius of the neighboring modules by the circle packing algorithm to enable this packing, which in turn gives a gradient of radii.
3. The height of the module: Fixed in this experiment.
4. The amount of supporting inner patterns: Not interfaced by the interactive system. Totally dependent on the radius of the module.
5. The radius of the inner hole of the module: The position in z-direction to the drawing plane of the right hand determines the radius of the inner hole. This works on a threshold area which affects neighboring modules to create a gradient.
6. The curvature of the inner pattern: The position in z-direction to the drawing plane of the left hand determines the radius of the inner hole. This works on a threshold area which affects neighboring modules to create a gradient.
7. The shift/twist of layers: The speed of movement in z-direction to the drawing plane of the hand determines the amount of twist. This works on a threshold area which affects neighboring modules to create a gradient (see image 9).
8. The shrinkage: Not interfaced by the interactive system. Totally dependent on the material, firing and glazing.

Rules were implemented that checked, for instance, whether a module already existed at a gestured position. If so, the already existing modules and any interrelations between them were affected by the movement. If modules are left untouched, then they will, over time, gradually untwist and shrink until they finally disappear. This behavior constantly engages the user, and presents an effective means to create a dynamic interplay between user and system.

When a desired layout is formed the user steps out of the drawing volume and stops the system. The captured pattern is then exported as G-Code and sent to the RapMan printer.

Exhibition
For dissemination in an exhibition the compositions of ceramic modules were mounted in laser cut transparent acrylic boards (see image 10) based on three different captured stills.

The transparent acrylic boards emphasized the lightness and flow in which the modules and the captured composition were made. The light movements of the hands were reflected in the smooth changes in size and pattern of the modules.

At the same time, and as a contrast, the materiality made the movement of the hands present. The strong materiality was developed in interplay with strong light coming through the ornament. They were light filters playing in and through the glossy glaze. In that way, the filigrainy, made by the printed ceramic, fulfilled the performative and aesthetic purposes.

The exhibit showed and emphasized the quality of the computational system to negotiate between the design intent, expressed through the movement of the designer’s hands, the 3d printing process and the materiality.

Reflection and Conclusion
The focus of the research was the investigation into the relationship between crafting materiality and its digital representation, and how experiential knowledge of crafts, rooted in ceramics, can be transformed and utilized in the use of digital technologies.

We have explored how novel digital approaches can create new interfaces between the human, space and the material. For this purpose, we have utilized a Kinect for capturing movements of the designer’s hands, the graphical programming interface, Grasshopper, for developing an interactive system, and a RapMan 3D printer for printing in clay.

Through experimentation we developed a computational system for designing wall-like compositions made up by modules in ceramics that modulated light.

In this project we have explored materiality within digital technology in an extended way. Firstly, being the result of the interaction of a designer with the responding matter (in this case clay) and secondly, the process (3D printing, firing and glazing). The research provides insights into how these concepts can be
transformed into current digital practice when constituting material processes are becoming integral part of the design genesis.

Prototyping gave an understanding for the needs of an inner stabilizing pattern of the modules, which at the same time functioned as ornament and light filter. A parametric module has been linked to an interactive computational system that negotiates between the movement of the designer’s hands and the 3d clay printing process. In this way, the hand of the designer can be traced and modules laid out according to the movements.

This link provided a means to transfer the position that bodily movement has in traditional craft processes into the realm of digital tools. It became meaningful as a mediator of complexity. The different ways the parameters can be linked reflects unforeseen complexity that can emerge by interaction. The complexity is to be experienced by the physical interaction through the movement of the hands. Thus, the experiment shows how the involvement of the body is being exploited in the use of digital technology based on the idea that crafting and execution is a unity that is intuitive and humanistic.

Bodily engagement provided a powerful means to gain overall control. This, as a single gesture, could control multiple parameters across a full set of many modules. In our exploration of the computational system we found it a challenge to identify how many parameters can be directly controlled by the hands at one time. We found that the selection of too many can easily create the feeling of random selection and a loss of control. It was, furthermore, a challenge to validate how many parameters make sense in an artistic expression. We found that too many different expressions weaken the power of the artistic result.

The developed interactive system reached it limits when the designers’ focus shifted from the overall to the particular. The notion of gradual refinement, constitutional to many artistic practices, is not supported by the developed interactive tool. The setup of the parametric system allowed, when needed, a shift to more appropriate tools of refinement.

The main finding was the potential in the use of the parametric setup that directly informs ornamentation by the movement of the hands. Through the interaction the size and pattern of the module emerge and change in real time in smooth steps according to the movement of the hands. At the same time and as a dynamic contrast the materiality in the 3d printed and glazed modules made the movement of the hands very present.

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References

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Crafting Data Stories

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Expanded Craft
The notion of traditional, material craft practice is shifting to embrace new directions that work across media and through digital networks. This expansion includes objects that incorporate techniques, tools and processes from electronic and digital domains, and integrates knowledge associated with these fields. Increasingly, physical, tangible pieces are the product of more than one individual. They are the result of several people using their combined skills to connect what might be perceived as disparate ideas and working practices. The work explores digital and handmade making practices; forms that mediate between physical, digital & analogue worlds. The resurgence of interest in craft practice is related to the proliferation and access to those technologies used to disseminate ideas and connect individuals and groups.

As an artist I wanted to explore the visual and conceptual possibilities inherent in information visualisation to determine a more practical engagement with data. To understand information visualisation as a tool to detect and uncover hidden patterns, and reveal them through the aesthetics of imagery and crafted objects. The use of technologies and applications that capture and shape digital information are pivotal in manipulating data that could be used as a *material* to work with. The result is the generation of tangible objects that respond to and reference their computational origins. The communicative potential of visuals being used to enable *stories* to emerge within data and detect messages lying beneath the surface. The question being set by the project was: how could a representation of data exist in tangible form? A physical rendering required a translation of digital information into a shape that could be constructed and fabricated using traditional methods. The tangible nature of the representation relates our experience of mediated communication to a crafted object. By placing digital information in a human, physical context embedded histories, stories and patterns are revealed. Stories surrounding collective activity and behaviour are shaped and presented in new contexts.

Digital Identity & Data Stories
The Internet has been referred to by O'Reilly (2007) as a ‘programmable environment for everyone’, using data sources that can be reused in a variety of forms and configurations. Social media platforms such as Instagram, Flickr or Twitter are repositories of digital...
information based on rapidly updated, dynamic, user-generated content. There are few barriers to entry and users from all ages and backgrounds can join these social networks and contribute media. Media is stored on the respective host servers and can be retrieved and analysed using Application Programming Interfaces (APIs). APIs are used by developers to interrogate content and repurpose or remix it into new forms. Although the users of services such as Instagram maintain rights of ownership over their photos, there is an ambiguity around how other users or third parties may use their photos once they become publicly available. For the purposes of this project, I worked with a developer to retrieve photos from Instagram via the API. The work actively embraced the knowledge that appropriated media was produced by many users to highlight the collective origin of the resulting pieces.

An exploration of digital identity was the conceptual incentive for the data collection and analysis process. To probe evolving digital identities, the work explored the freedom we feel to express ourselves online through the production of personal media content. Personal content is user generated material such as photos, music, drawing, video and text in the form of comments, status updates and the like. Users are able to create rich, expressive content that communicates stories about their lives and becomes a constituent part of the self. Meaningful dialogue and exchange with others in a shared network space is as important as offline communication. To get a complete picture we should take account of content sharing, comments and responses made by others, number of friends/followers per user and even the number of likes a particular item of content has accrued. Quiggin and Hunter (2007) analyse our motivations for contributing personal content to social media networks and suggest self expression and social interaction as the overriding factors. This removes money and commerce as an incentive for contribution that enables people to produce and upload content in a freely expressive manner.

The collective nature of social media networks and the open architectures on which they are built ensures that all uploaded media can be made available and actively retrieved and stored in a model of reuse suggested by O’Reilly. In order to narrow down the field of enquiry and produce something achievable, the work concentrated on mapping content from a single social media network. Instagram is a microblogging, peer production, user-generated social networking tool. It is a space in which users can project a virtual identity, interact with others, create updates, share and comment on media uploaded by themselves and others. Widely adopted by users from across demographic groups, it has been experiencing huge growth and popularity. Additionally, Instagram is used by social scientists to study social and cultural patterns of behaviour and was well positioned as a rich visual source.

**Revealing Visual Patterns**

Visualisation tools and graphing techniques are required to explore patterns and trends in data and datasets. Standard visualisation techniques, such as bar charts, tree maps or scatter graphs, were discounted as restrictive methods for presenting visual patterns in imagery and inappropriate for highlighting the visual characteristics of image sets and their contents.

If you analyse media content based on visual parameters, i.e. colour, shape or contrast, it becomes easier to see emerging patterns. This approach enables you to experience the media set as a whole rather than simply as individual parts, and provides a snapshot picture of user-generated content. It provides a more complete sense of the images in terms of interpreting their intrinsic qualities based on a unique set of attributes.

Uploaded media and users profiles have been assigned with tags, comments, number of follows etc. by the user and assigned with metadata by the Instagram platform. In this instance, we used the API to retrieve media uploaded with those tags related to *most popular* or *least popular*. Web data related to users and uploaded media is unique and is measurable, searchable, trackable and quantifiable. In this study, web data could be analysed as an indicator of personal expressive use of media and to help understand modes of communication and behaviour.

Users annotation of images using tags is often imprecise but still acts as a descriptor for that image and can be used as a method of assigning value and communicating expression. Tags carry semantic meaning about the content of media, which allows search engines and web agents to assign significance to that content.

Mosaic was the tag chosen for the visual study as its semantic meaning relates to a montage of smaller media pieced together to create a larger whole. This suggested the holistic overview we were attempting through visualisation; an active web of affinities that is constantly shaped and reshaped by users. Another consideration was the Instagram API, which limits the number of hourly queries you can perform. #mosaic was a small enough media-set of roughly 322,000
photos, that was enough to reflect the diversity of photos uploaded while still being manageable. To refine the set further, we retrieved only those photos tagged for a particular month. We retrieved a total of 1,544 photos for July 2013.

ImageJ is a public domain, open-source image processing programme developed by City University of New York Software Studies Initiative in 2009. They describe ImageJ as a tool for the exploratory analysis of large image and video collections using digital image processing and visualisation. ImageJ plots large image sets using graphs, such as scatter plots or timelines. It is designed to work alongside other plugins that extend its functionality and enable greater investigation into attributes being explored. We used ImageJ and QTIP to extract features and colour parameters from images retrieved from Instagram. Hue, brightness, saturation, and contrast were some of the features analysed by QTIP, that resulted in a dataset which could be reused by other applications for further analysis and pattern generation.

Existing visualisation tools show data as points, lines, and bars. ImagePlot’s visualisations show the actual images in your collection. The images can be scaled to any size and organised in any order - according to their dates, content, visual characteristics, etc. (CUNY, 2009)

By plotting the Instagram photos onto a graph we could holistically analyse them and pick out underlying patterns. Each photo was positioned along the vertical Y axis according to its brightness value, and along the horizontal X axis according to its hue value.

The resulting visualisation was a representation and mapping of the tag #mosaic on a spectrum according to hue and brightness. The preponderance of warm reds and oranges were the strongest colour range. During the demonstration participants speculated why different colour clusters might be more or less dominant. They suggested the Instagram interface could affect the tonal colour range of images through use of filters that users can apply to their photos.

However, the time of year could also be a factor in the number and variety of tonal range related to seasonal variation. Influences caused by natural, urban or skin tone factors being represented in each photo could also have some significance. The visualisation gives an impression of dynamic web data, which makes visible a body of images that can be appreciated as an exploration of expressive content hinting not at one clear interpretation, but rather many possibilities.

Tangible Data

The ImageJ visualisation was to be used as a structure and visual map to inform the creation of a tangible crafted piece. To build on this, another process of translation was required to distill the colour parameters into pure colour information and RGB values. Visualisation relies on the principle of reduction in order to express the properties of the whole. You sacrifice specifics for the sake of revealing and making visible the invisible patterns in data. Working with a developer, D3 was the visualisation application chosen to translate the colour values obtained from the previous process. The values were plotted as radial coordinates onto an SVG image using a javascript library. We used the average colour value to determine the angle and the average saturation to determine the radius, and then plotted an arc of the colour described by that hue, saturation and a constant brightness.
Each visualisation technique and application use spatial variables, such as position, size, shape or colour, to plot images or shapes along horizontal and vertical axes. We selected the properties of the web data we would most like to plot and depicted those properties to reveal the most important patterns and relationships. The principle of reduction is a key information visualisation technique which, as Manovich states:

“[u]ses graphical primitives such as points, straight lines, curves, and simple geometric shapes to stand in for objects and relations between them.” (2011)

When producing the physical piece, the decision to use embroidery on canvas referenced the possibilities for correspondence between the simplified and reduced visual forms. Highlighting relationships between the pixels that make up a digital image and the stitches that make up an embroidered canvas would facilitate the materialised representation of digital information. Colour could also be translated directly from screen-based RGB colour space into embroidery thread.

To convert the visualisation to canvas a correspondence between the imagery and the stitches was achieved through a pixelation process that limits the number of colours. Each pixel corresponded to a stitch and the colours corresponded to a thread. The overall feeling is of an impression of colour dominance portrayed in the tapestry. As a simulation of web data, the resulting embroidery conveys a feeling of tactility and tangibility that is unlike the ephemeral information it depicts. If you consider all the translations and conversions together as a journey of visual information, the process moves from concrete, into intangible form and back to concrete form. The original mosaic imagery taken from Instagram referenced real, physical objects.

In a sense, the original mosaic objects have been through a process of transformation to re-define materialities that move back and forth between digital and physical manifestations and render tangible what was previously an intangible set of numbers.

Implications for Craft Practice

The process of retrieving data, sculpting it and representing it in physical form became the focus and outcome of the research. The demonstration interrogated the processes behind the creation of the data, graphical representations and the fabrication of crafted objects. It explained the source of the data, decisions that were made to shape it and how connections were made between data sets. It illustrated an approach to extending data visualisation into the realm of the tangible that go beyond the visual to suggest a more multi-sensory approach.

The process that has been described attempted to capture a moment in data time, which is made possible through complex digital functions and queries. Each stage of the process was overseen by more than one person and hints at the collaborative nature of future craft practice. Stages relied on tacit knowledge of information manipulation and digital processing to produce readable, understandable forms. If a true understanding of any medium is attained through habitual, often tedious, involvement then the digital processing required in this research is an example of craft practice. It references the skill involved in achieving a creative result in which so many phases contribute to the whole. ‘Subjugating so many synchronised moves to a creative intent is a yet greater skill’ (McCullough, 1998). The representations provided a snapshot of the social and visual nature of our interactions in a multi-layered, mediated reality.

The future potential of craft is to occupy a position that examines the boundaries, interactions and tensions between atoms and bits. As its value becomes more prominent craft practice will acknowledge a flow of thought and knowledge into objects that connects them to other fields. To make connections with intangible, dynamic currents of activity will propel the objects we make into sharp relief. As Susanne Kuchler (2005) outlines:

“No longer can we regard things as passive receptacles of discursive thought; rather, as we have indeed long suspected, thought can conduct itself in things, and things can be thought like.”

References


Lucie Hernandez is an artist and maker with an interest in working with technology as a material form. Since training as a textile artist, she has been lecturing on computer art and interactive design courses and is a fellow of the HEA. She recently began an AHRC 3D3 practice-based PhD in the Autonomic Research Group at Falmouth University. This allows her to investigate the value of craft to the development of nuanced technological forms and tangible interfaces.
**Match Making: Broadening cultural exchange opportunities through digital access to crafts**

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**An Overview of the reSide Residency**

The reSide residency was a Creative Scotland funded exchange programme for makers between Scotland and India during August 2012 to May 2013. It had the objective of facilitating high quality production and knowledge exchange around making by bringing together practitioners with educational, professional and wider community-based making networks particular to each country. The programme allowed two textile based designer makers from Scotland, and two practitioners from India to pursue two separate four-week periods of practice in the respective host country, with considerable emphasis placed on providing opportunities for audience engagement and broadening of cultural experience at all levels of making. During the second residency phase, practitioners engaged with hobbyists and industry leaders, high school pupils and university researchers in the Scottish Borders, while interacting with traditional artisans in Kutch, Gujarat, collaborating with experimental design in Calcutta and engaging with Indian models of students-grassroots interface. The enduring success of the programme was considered to be dependent on developing a collaborative atmosphere to allow immersion into another culture and develop from it, as part of a socially situated learning process, further consideration of dissemination of their learning with an audience that went beyond the immediate participants involved (For a detailed analysis of the outcomes achieved in school workshops and adult community workshops in Scotland, see Greru and Kalkreuter 2013). One challenge recognised from the outset was to keep this momentum going when the physical residencies would be over.

In this paper we catalogue key thoughts and practices that emerged in the analogue engagements during the residency, while also scrutinising the digital engagement that started during the project. Its effectiveness as a means of furthering collaborative practice was considered, namely how social media platforms as extensions of analogue experiences were used to arouse lasting engagements with practitioners and the public when such media have been largely overlooked with regard to e-learning (Lewis et al., 2010). Key questions to scrutinise the online engagement by are:

1. Is the information provided on an online platform sufficient to create a meaningful understanding of

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**Abstract**

The paper describes research conducted into the engagement potential of social networks in the field of cultural exchange about making. It was conducted alongside a Creative Scotland funded residency programme between designers in India and Scotland that had public engagement as one of its aims. During the residencies, which might be described as the analogue phase of the reSide project, the occurrence of appresentation of cultures was identified as a key factor in successful engagement of the public in a culturally informed making process. The potential of social media and other digital tools to prolong and enhance this environment is the object of this paper. A qualitative approach of participant observations and content analysis of interview data from the digital media used by the residency team was applied, and social network and hyperlink analysis was conducted through open source software NodeXL with visualisation through Gephi. Textual data analysis of individual and collective dialogue amongst large groups was also employed. Analysis revealed that what was shared online in this project did not fully replicate all the descriptive and layered information afforded to participants who were witnessing and sensing the events live and in person, with far distant geographic locations and dramatically diverse practices being suspected to be factors. However, a certain degree of the implicit knowledge often considered as a key achievement of the analogue experience of residency was clearly identified as present in online users as they engaged with previously unknown or assumed characteristics of culture through live debate of various viewpoints and through multiple stimuli. The paper concludes by indicating the need for further study of the motivations and techniques employed by emerging collaborative cultures such as the one considered here.

**Keywords:** Residency, cross-cultures, digital- engagements, appresentation, social media.
another culture, and does it equate to a cultural experience?

2. In order to inform making, is the information and knowledge provided through images and texts or colloquial conversations an adequate representation of culture?

The Methodology
A qualitative approach of participant observations and content analysis of interview data was employed in addition to monitoring online engagements of the reSide residency through personal web blogs and the interactive Facebook page of the project that became a regular discussion forum during and after the residency. As part of this, web forum, social network and hyperlink analysis (Hine, 2000; Hine, 2008), open source software NodeXL with visualisation through Gephi was employed in addition to textual data analysis of individual and collective dialogue amongst large groups. Conducting the research from the standpoint of a Facebook fan page, in what might be termed virtual ethnography (ibid.), allowed us to monitor the involvement of practitioners, hobbyists and other interest groups from local and global contexts from within the platform.

Cross Cultural Residencies
Residencies are often praised for their benefits as well as criticised for being resource intensive (Horn, 2006). Cross-cultural exchanges between practitioners to support cultural trade and sharing of mutual knowledge and practices were widely seen as building awareness across boundaries, and producing wider benefits from knowledge exchange to movement of ideas and creative productions between countries (Hare Duke & Theophilus, 2013). Hare Duke and Theophilus favour residency experiences as meaningful legacies over one-way curatorial tourism. Our paper explores how these legacies might be carried through digital engagement, which complements and follows on from a resource intensive, longitudinal, knowledge exchange experience in analogue format.

What Practitioners Learnt from the Analogue Engagements:

Understanding Craft from within Communities
The Scottish practitioners realized the importance of communities of practice that still prevails in Indian society that occurs while sitting, eating and living with the artisanal communities. Tradition was experienced as a generational and socially immersive activity rather than its perception as curatorial practice in museums or archives in Scotland.

The time spent in Kutch was a huge contrast to the impersonal city. I had instant and continuing contact with people in their daily routines and with artists in their workspaces. It was here that I began to understand how artisan communities operate. (Scottish designer maker) (Image 1)

The sensitivity the practitioners developed with another culture was more important where they found reasoning behind each activity, this increased cautiousness in their approach when perceiving a culture, both material and conceptual.

Making as Conversation
Rather than the result of a personal struggle between technology, materials, aesthetics, creativity and the self, making was experienced as a means of conversation in and with the community, with interesting outcomes for individual risk but also credit.

Making as Conversation
Rather than the result of a personal struggle between technology, materials, aesthetics, creativity and the self, making was experienced as a means of conversation in and with the community, with interesting outcomes for individual risk but also credit.

The women artisans in particular interested me a lot, the way they use textile as a way to meet, as a way to create and a way to communicate was incredibly inspiring. (Scottish Designer)

I don't think we ever share in the Western community. Especially in the textile courses, it's really competitive. If I want to be the best and then I don't want them to use my techniques... But People can enjoy things in a more rounded way like in those communities. (Scottish Designer) (Image 2)
This understanding developed as a key enrichment during the residency for the Scottish practitioners as they sought to share their making with the wider public through local and personal networks. Organised workshops took the spirit of community sharing. Co-created meanings were found through collective making and sharing of skills as well as ideas.

Appreciation of Culture and Craft: Contrasting own and others’ practices

In this context, it became important to all practitioners to evaluate how one could contribute their own thoughts and practices to collaborative encounters, and how freedom of choice and original design relate to good design when seen in the context of David Pye’s conversation with Frayling on how making good design is like making ‘something new, something old, something else, where it is not about copying the tradition but developing on it instead – on what is been done.’ (Frayling, 2012, p.95-96)

On my return to Bangalore (after finishing the first phase of the residency in Scotland) it was time to reflect and rephrase the project proposal. It was also an opportunity to revisit some old forgotten practices such as journaling, sketching & painting. Experimenting with the local silk in combination with wool was a new exciting direction to take.

(Indian designer maker)

I enjoyed the natural beauty of the land. I saw prosperity and meticulous infrastructure and small things made me aware of my own ‘Indianness.’ In the silence, I saw an absence of people while life back home was grounded in people… people and children buzzing all around! I realised I needed that context to create. I appreciated that in India despite all the societal pressures, the struggle for livelihood, the dirt, the noise, the absence of infrastructure, despite all of this, one could still create, one could still make the most of things and still be happy.

(Indian artisan) (Image 3)

Analogical immersion here led to a realisation process of one’s own making through material and conceptual appreciation of another culture, realised through some degree of appresentation, in addition to what is presented directly. Tim Dant (2012, p.438) describes

means of creating awareness and the idea of sharedness when he explains:

if the other person was from a very different culture, for example one in which there were few cars, or few new and well maintained cars, then her apperceptions would be different and her perceptions would be less apparent for me. Appresentation depends on sharing a very similar stock of knowledge and, the further away the other’s experience, the less likely the person will see things in the same way.

Marton and Booth (1997, p.99) liken appresentation to how we perceive a table when looking at it from above, because ‘the experience is not of a two-dimensional surface of a table, but of a table’. In other words, the external experience of seeing the surface of a table from above triggers a much richer internal experience that is more effective in allowing us to understand the phenomena present, because it takes into account contextual and prior experiences in addition to what is presented to us (ibid., p.99). From our perspective, it is important to consider what experiences can build a shared stock of knowledge. Within any learning process our internal and external experiences do come to matter in the way we perceive a culture or a cultural object. Allowing practitioners to experience the critical aspects of cultures by a process of total immersion actually work towards informing this multidimensional understanding, more so than in much debated craft and design interventions where contact remains brief and superficial.

To what extent could these analogue experiences be extended into the virtual environment of reSide?

Digital Engagements of the reSide

In 21st-century maker cultures, digital engagements are sometimes viewed as detrimental to the analogue culture (Luckman, 2013, pp.251-252). On the other hand, online platforms like websites are seen by some as rather ‘underutilised’ modes of engagements because creating public digital engagements are considered a daunting task to achieve within residency experiences (Hare Duke & Theophilus, 2013, p.210).

Little doubt exists that the use of digital media and technology in creating cultural experiences is an emerging practice, however, and Rachel Charlotte Smith suggests the true challenge does not lie in applying technology to existing practise to enhance the user experience, but to understand the ‘emergence, creation and conceptualisation of cultural heritage’ within digital engagements (Smith, 2013, p.117).

Within the reSide residency, the participants maintained their personal web blogs as part of the project, but were supported by a central Facebook page. As Hare and Theophilus (2013) have suggested, we had doubts about how much trust can be given to interactions between the larger public and self-publication.

In recreating a virtual community, the public’s
increased use of internet communications and social media, in the context of production and consumption (Lewis et al., 2010), has been described in the concept of ‘prosumption’ in a ‘prosumer-society’ (Zajc, 2013), or through what Gregory Cameron (2011, p.336) calls a ‘democratic public sphere’. This is a central consideration in our study as immersion in community has been shown to be a central gain of the analogue residencies.

**How the Digital Engagement Worked**

The ReSlde Facebook fan page was utilized as the main method of online engagement from the inception of the residency, with all four practitioners given access rights for contribution to content. The makers published their own work and found inspiration during their cultural explorations in each society, with plentiful conversations starting on their initial comparisons between Eastern and Western practices. With the initial content validated as authentic by the residents’ immersive experiences, fans and followers of the page actively contributed through deeper enquiry as well as reporting related experiences. This reflects Lessig’s (2004) observation on how social media are inviting users to, by means of reading, also write (cited by Zajc, 2013). Active participation is preceded in this model by consumption (Zajc, 2013). The latter possible only in digital, not analogue format for anybody but the participants of the residency itself.

The use of social media during the residency brought great insight into how the online and offline engagements could be viewed in a complementary manner as global discussions and communicating with a personal intimacy existed side-by-side and kept prompting participation at different levels. In this context, one (adult) group’s off-line engagement with the residents were shaped by on-line engagements during and after the residency project as they continued to share what had been observed in the analogue meetings as communities of practice. The digital engagements populated the idea of sharing rather than copying, where collective contribution of making was enjoyed by all going beyond the individual making practices (Image 4).

**Digital Engagements and Appresentating a Culture**

The appresentation, as seen in the analogue cultures, was also found to be useful in understanding the digital engagements. The on-screen presence of reSlde through textual and visual branding on the social media became available to anyone who followed it. By ways of liking, sharing, commenting, tagging or simply reposting hyperlinks and web links, screens were ‘walked’ (Cetina & Bruegger, 2002a, p.396), and users were enabled to distinguish themselves as bona fide participants of the project without necessarily having actively participated. In other words, what benefits a project (or product) in terms of gaining publicity through social media sharing also has benefits for those choosing to share as they choose a level of involvement that goes beyond mere passive consumption and moves into the realm of prosuming.

By bringing different engagements, conversations and presentation onto a public social media platform some immersive experiences could be connected; allowing a large community to be present identically in all places whether they were in Scotland, India or any other country in the world. This was dependent on whether they had direct links to the project, or whether they had actively contributed or not (Cetina & Bruegger, 2002a, p.395).

Appresentation also works through online platforms, according to Knorr Cetina and Bruegger (2001, p.183), because:

screens are not, in their core elements representing a reality out there, but are constructive of it… we take the screen to be an appresentational device that enhances and routinizes such relationships… where the screen brings a geographically dispersed and invisible market close to participants, rendering it interactionally or response present (Cetina & Bruegger, 2002b, p.183).

Therefore, in the residency, digital engagement and the maker culture is constructed by assembling experiences from people of different disciplines whether taking part directly or passively. It includes makers, craft lovers, craft enthusiasts, institutions, researchers and businesses, and the public at large. It contributes by creating a ‘site’ of consumption and (elective) production of craft work and culture rather than acting merely as a ‘medium’ of transmission of images and textual data (Cetina & Bruegger, 2001, p.183).

The digital experience empowers each user by freely offering a position on the online community without the scrutiny and potential exposure of inadequacy often associated with analogue sharing of cultural activity. By becoming a player in its overlapping networks; brings benefits beyond the selected group of people in the analogue engagements (Cetina & Bruegger, 2002b, p.164). The digital experience allows observers, gently and without pressure, to become participants by incrementally growing their thoughts on other participants into finally daring to propose their own contents if ever they choose to do so, but without the embarrassment of remaining silent forever.
Images to Facilitate Remote Immersion

The digital platform also allowed abandoned use of images and videos, for example of time spent in India by the Scottish practitioners who shared footage and images of local festivals, like the Navaratri festival\(^2\) and the garba dancing\(^3\), or the traditional Rabari\(^4\) wedding festivals. This documented details of different maker techniques as well as the rural Indian community they were associated with in a way that provided an immersive experience virtually, and allowed at least parts of the analogue residency experience to be transferred on to a digital platform.

Interestingly, some practitioners provided evidence on their personal maker practices in reaction to these documented local cultures by posting detailed descriptions of mood boards, videos on experimental design approach, and material and conceptual explorations alongside moving images of what they had experienced. (Image 5)

Another Scottish practitioner provided a detailed description of the natural indigo dying techniques she learnt in Kutch to bring insight into how she used it during her own design process. (Image 6)

This information was commented on as important by other users in India and in Scotland as a way to witness how traditional practices might be contemporised, informing interesting debates on craft and design interventions at times when innovation is claimed to be largely associated with Western modernists values deploying first world design agendas for local cultures (Tunstall, 2013). Once again, the social media platform allowed these discussions to be shared democratically.

Importantly, during the time spent in Scotland, the Indian practitioners wanted to explicate the various types of design meetings they had by posting these events online. Posts varied from capturing the natural beauty of Scotland as contrasting to the arid desert experiences in Kutch, to design experiences in museums, archives and private design studios in Scotland. Online posts by the Indian residents tended to concentrate on communicating aspects of their changed practices rather than materialising their broader cultural experiences through actual product. A participating Indian designer, for example, posted her new open studio concept that was started after the residency (Image 7), and an Indian artisan supplied images of sharing his Scottish experience with his community (Image 8).

Did the Digital Platform Create Digi-cultures?

It would be overly optimistic to conclude that reSIde digital engagements created a full online appresentation of analogue cultural experiences when compared to the highly personal and multisensory immersion experienced by the residents during their two months (Cetina & Bruegger, 2002a). Even though great efforts were made to make the materiality of the screen come alive with textual and visual data, the transparency or the see through quality of the information one shares on the screen must be considered rather one dimensional in comparison to living and working in a culture 24/7 (ibid).

What can be shared online never quite offers equal opportunities. All the descriptive and layered information equivalent to witnessing and sensing the events, especially when taking place across such different geographic locations, is often lost (Cetina & Bruegger 2002a & 2001). Therefore, the research poses two questions to be considered on how much one can experience of another culture within a digital engagement.

1. Is the information provided on an online platform sufficient to create a meaningful understanding of another culture, and does it equate to a cultural experience?

2. Is the information and knowledge provided through images and texts or colloquial conversations an adequate representation of culture to inform making?
Analysing the reSide Facebook Fan Page

We attempted to bring insight into the above two questions by analysing the Facebook page using open source software NodeXL, before visualising it using Gephi. This allowed observation, analysis and visual interpretation of the connectivity between the 283 members of the fan page on this social platform. The most engaged group were between the ages of 25–34. Identifying key influential people in terms of co-commenting and co-liking, we requested their feedback on how the reSide residency’s online platform helped them to understand another culture and to what extent it influenced their practices.

The answers demonstrate that reSide on Facebook has added cultural knowledge as well as arousing further interest in the culture perceived as other. According to one comment, the images and other contents formed rather an exotic experience and generally opened minds, allowing a glance at cultural exploration without ever moving:

*It gave me a look into a place I had only heard of, but have never been. It made me more open to exploring culture in other places.*

Other participants reported a direct influence on their own practice as well as a broadening of the mind:

*More open and broadened my thoughts pattern and creative output*

A third indicated the digital immersion as a possible first step before actual travel:

*My practice now is not as a textile designer but as an artist and the visual images inspired my use of colour. I would love to go to India and see the colours in reality.*

Some of the online residency’s social media practices created larger conversations between members as one user said ‘I read and share to make others aware’. Describing collective dialogue, which is important for collaborative creations, and particularly in problem solving conditions (Lewis et al., 2010). Images were at times used to stimulate and facilitate a collective problem solving atmosphere in virtual territory (Image 9). According to Lewis et al. (2010) it is these collaborative problem solving cultures which ignite innovations and change.

Further, we saw the platforms used for encouragement, advertising to participate in related analogue events, to seek more information and virtually participate in the events at distance. The sense of appreciation lavished on many such events either through participating in conversations, or simply liking each other’s submissions provided a cornerstone for the sustainment of the online platform.

The online exp of ReSide helped me understand the long term output of the entire programme, how it has benefitted all involved over a period of time. I am particularly inspired to see how much effort … ![The Scottish designer maker] has put in the project even post her visit to India….!

The importance of sharing the visual content on social media, or any digital platform was key where many participants saw the benefits of visual culture:

*The interactions and postings made me appreciate and understand another culture more with the visual content than words. Or ‘The images update on FB is a quick way of following the story. After all a picture says a million words.*

The photo albums that were posted by the reSide residency practitioners were analogous to the physical journal entry experience, which seeks to elicit, document or develop a personal approach to understanding creative inspiration, here located in the understanding of another culture.

As the practitioners shared what they keenly captured as the critical data through images, representing the most interesting aspects of life styles and the making culture, such collated albums created multi-layered scenes that online users could build and comment on. Different meanings and experiences that were exchanged, brokered and negotiated created a digital learning environment (Lewis et al., 2010).

**Discussion**

Uploading intensely and intimately captured events on social media and inviting a community of users to...
share, comment, contribute or even just consume, has been shown to add inclusive and lasting dimensions to the reSide residency project. The community succeeded in evoking a maker culture that was ‘represented, created and consumed’ through the images and texts which were generated, shared and understood on an online platform (Woermann, 2012, p.621). The ‘micro-communications’ like nature of social media served as a relatively barrier free insight into individual practices and perceptions, which big events might struggle to achieve as building a social eco system would first be required.

A picture was generated through a collection of ‘lots of small bits of information about people and communities’ that can help inform choices made at whatever level or degree appropriate and possible for each participant (Lewis et al., 2010, p.355). Here, another culture becomes appresented on the screen as a whole (Marton and Booth, 1997), to whatever degree, and from whatever angle a participant chooses to engage with the collection of diverse interactions and contributions. What is presented on the screen of the social media platform is not just a collection of images from the individual residency experience, but instead becomes a collective immersion in analogue experiences and the digital reactions they trigger (Image 10).

As Knorr Cetina and Bruegger (2002a, p.397) explain, the on-screen representation becomes a ‘wired, programmed and content-filled, textually elaborated, surface that fascinates through its ability to frame and present a world’. This contributes to the creation of a developing culture experienced by all who participate, and necessarily different to what this culture actually is like, or how it is experienced by just some. For a total immersion into the cultural experience, the on-screen presentations should serve to create an experience of integration and accumulation of knowledge that individuals achieve through embodied processing when they develop ‘implicit knowledge’ (Cetina & Bruegger, 2001, p.193).

Creation of such ‘implicit knowledge’ is considered a key achievement of the analogue experience of residency, but was also clearly present in online users as they engaged with previously unknown or assumed characteristics of culture through live debate of various viewpoints and through multiple stimuli (Dant, 2012). What was achieved through digital engagement of participants might be seen as an initiation, or ‘common ground’ in creating a ‘shared perspective that helps make sense of novel experiences and cultural categories’ as explained by Lewis et al. (2010, p.364).

The running of the digital platform during and after the residency programme had been initiated as a relatively sustainable and accessible mode of knowledge economy that is democratic and truly global where the residencies were necessarily elitist and local. It served as collating ‘dispersed and fragmented local knowledge’ into a distributed knowledge system (Cetina & Bruegger, 2001, p.193) irrespective of the physical, temporal and spatial. While post residency, the online engagements are an example of lasting debate as participants are still updating their different creative trajectories on the Facebook fan page. We must note that the online engagements were much livelier during the residency, particularly on those events when it was linked up with off-line community engagement projects.

**Limitations of Digital Engagements**

To support successful digital engagements other aspects of developing successful collaborative digital narratives must be considered. A question raised by Knorr Cetina and Bruegger (2002b, p.164) centre on how the human relationships of analogue encounters might be infringed on screen by non-human others within the digital engagements. The workshop sessions that ran alongside the residencies and the online platforms connected both on-line and off-line making might have served to bridge this gap in certain ways. Future research might investigate how users produce and consume the digital making cultures in analogue ways beyond the project.

Another constraint rests with the linear format of Facebook communications where content gets archived as more posts get added.
Finally, and since we are speaking of cross cultural knowledge engagements, accessibility to technology and preferences do matter for effective engagement. Communications might be hindered by infrastructural facilities and literacy rate of the people who get involved across the boundaries. A few years ago Lewis et al. (2010) reminded us that even though digital smart phone accessibility was high in Europe, it remained largely limited in other parts of the world. We can add to this viewpoint the results from a mini survey of some artisans in Kutch in 2012 (Greru, 2012) to emphasise the emergence of information and communication technologies in terms of sharing and communicating craft skills to help with their creative craft productions. The results showed the increased preference and attention the rural artisans had developed over ICT methods and it was beyond what we initially anticipated (Image 11).

With such growing interest and enthusiasm to learn and use technology, we are hopeful that rising technological accessibility and mediation may not only create democratic maker practices, but will also generate democratic maker cultures through increased communications and knowledge sharing where analogue meetings are out of the question. Future research might look into ways of refining such collaborative cultures.

References


Britta Kalkreuter, graduated with a PhD in Art History from Cologne University after spending some time in Ireland studying and researching at Trinity College Dublin. She is Associate Professor in Context at the School of Textiles and Design of Heriot-Watt University. Her research interests currently concentrate on design semantics, transnational education of design and semiotics of remote visual feedback for co-creation.

Chamithri Greru, MSc, is a PhD research student at Heriot Watt University, Scotland. Her work explores interactions between craft and design with a focus on knowledge management, and is carrying out research in Scotland, India and Sri Lanka. Chamithri also has a practice background as a designer in the fashion and apparel sector.

5. The survey was distributed among 39 artisans in Kutch. Twenty usable surveys were returned with a response rate of 66.6%. Out of this, 19% were female with a majority of male artisans.


Facebook deals pretty exclusively with ‘now’ so to see the development of the project you would need to scroll backwards from the bottom’, (Scottish designer maker).

<table>
<thead>
<tr>
<th>Preference for Using IT Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>They are not for crafters</td>
</tr>
<tr>
<td>No time to learn it</td>
</tr>
<tr>
<td>Too complicated</td>
</tr>
<tr>
<td>Don’t know but like to use it</td>
</tr>
<tr>
<td>Very helpful and we use it</td>
</tr>
</tbody>
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Image 11.
Knittstruments: Melodies of weaving

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Introduction
Observing knitting, we can see the workings of a special logic of assembly between the two knitting needles and the thread that follow certain protocols (von Busch, 2013). While knitting has been described as a rhythmic, slow, creating process, it seems less aimed to stimulate a knitter’s creativity. The main focus of this research is not concerned with the creation of new knitting patterns or the combination of various techniques, but on the individual bodily rhythm and the body as a tool in use during the knitting process. By intervening in the traditional process of the craft practice with four interactive interfaces that transform knitting into sound, we investigate how the addition of auditory feedback, which makes the knitters aware of their bodily movement, affects their performance and enhances creativity.

In this paper, we first present the different ways in which knitting can creatively stimulate a craft practitioner and reflect on a knitter’s embodied knowledge. By altering how the process of knitting is perceived, appealing to the embodied knowledge of the knitters, we believe that new kinds of creativity may be unlocked. We use the term knitting composition rather than knitting structure to account for musicality and leave room for improvisation in the definition that Tim Ingold provides for the latter: ‘Knitted structure is an outcome of repeated, controlled movement in the process of spinning and looping’ (2000). Needles, yarns and the knitters’ expertise, influenced by sonic feedback, are the instruments used to complete a knitted composition.

Research Question
The research questions that this paper aims to answer could be formulated as: To what degree can a skilled practice, and the tacit knowledge that characterises it, be faithfully translated into a different expressive domain? Can such a domain translation creatively influence the activity being performed?

Literature Review
Creativity and Knitting
Creativity assumes diverse definitions depending on the field of expertise in which it is referred to. It exists in an infinite variety of forms and thus, formulating explanations of particular aspects of creativity seems highly convenient (Hargreaves et al., 2012, p.10). In this study we understand creativity, on the one hand, as the production of novelty through the

Abstract
Knitting is a slow, rhythmic crafting process that reflects on the knitter’s skilled practice and embodied knowledge. Would it be possible to translate this knowledge into another language (that of music)? The key objectives of this paper are to analyse the role of the craftsman (knitter) and how it is influenced when the expressive domain of knitting is altered into music. To then investigate how an auditory feedback, which makes the knitters aware of their bodily movement, may affect their performance and trigger their creativity. The research is an ongoing process of multiple iterations based on action research and entails cycles of simultaneous data collection and analysis, which is based on the grounded theory methods of noting, coding and memoing. As a result, three different instruments (knittstruments) were assembled and tested in three different environments. Analysis of the data collected suggests substantial alterations in the knitters’ performance due to audio feedback at both an individual and group level, and improvisation in the process of making. The contribution of this research is a further examination of knitting practices, focused on the relation between creativity and skill, building upon the knitter’s embodied knowledge.

Keywords: Crafting, knitting, sound interface, skill practices, creativity.
Salustri and Rogers (2009) state that:

Knitting is loaded with tacit knowledge that speaks to us through our hands. It is both matter and process. If we observe knitting as the workings of a special logic of assembly between the two knitting needles and the thread that follow certain protocols (von Busch, 2013), then we read a knitted object as the creation of a knitting structure as if decoding a piece of text. Knitters follow specific knitting patterns and, it seems, a more methodical than creative activity. In that case, their creativity lies on the decision-making phase on colour variations, different qualities of yarns or the combination of different techniques. According to Ingold (Hallam & Ingold, 2007), it is ‘based on the recombination of already extant elements’. Highly experienced knitters can also create their own patterns; a phenomena which is quite rare and based both on their skilled practice and their experimental character.

**Knitting and its Rhythm**

Knitting has a rhythm that is based both on the pattern that the knitter follows, and the way the body engages in the activity of creating such a pattern. The rhythmic, slow process of creating a knitting piece reflects the individuals’ embodied knowledge and the degree of their skilled practice.

Experienced knitters hold the needles their own way, pulling the yarn in a specific manner, trying to minimise their movements in order to relax their bodies. They don’t seem to question how they knit, but simply rely on the various patterns, the techniques (knitting, crochet), the material properties and dimensions of the knitting needles according to the pattern, and the qualities and the colour of the yarn. Salustri and Rogers (2009) state that:

> Once we have learned to do something in a certain way, we will tend to do that thing the same way forever, or until a better way presents itself (and sometimes, not even then). In this way, we will tend to not try other ways to do a thing because we have learned one way of doing it.

Creating new patterns and experimenting with different knitting processes based on pattern generation enhance the knitter’s creativity that is based on the pattern generation and creation. Murphy elaborates on the curiosity of knitting, how it is always open for new forms of stitches. ‘Knitting is not merely an endless repetition of stitches and micro-patterns, but a rhythmic movement with different patterns of repetition, where one gets the result in action’ (2002).

According to Lefebvre, knitting is rhythm linked, on the one hand, to logical categories and mathematical calculations and, on the other, to the visceral and vital body (2004, p.14).

Apparently, every knitter has her individual rhythm and her unique way of knitting. In the flow of action (flow state) (Nakamura & Csikszentmihalyi, 2002), the body itself becomes transparent, as do the tools attached to it (Ingold, 2010), which in phenomenological terms could be expressed as the tools are ‘ready-at-hand’ (Heidegger, 1977). Knitters do not need to think about their action, they are unaware of their bodily movements; rather they just act, as if it were an involuntary reflex. According to Sennett (2008) if we ‘break the mold of fit-for-purpose’ for the tool in use then we open new possibilities and the imagination of the craftsman.

In the following experimental settings we were focusing on bodily skills and their representation as a direct coupling of action and perception, and examine how the awareness of bodily movements can trigger creativity in a performative setting.

**Methodology**

In order to gain a better understanding of the relationship between craftsman, knitter, tool and skill, three different instruments (knittstruments) were set up for the specific circumstances, and tested in three different environments. We conducted qualitative research and employed a multi-method approach of action research (Stringer, 1999) and grounded theory (Glasser & Strauss, 2008). Both methodologies are iterative processes where theory and practice are interlinked. Diagnosis and action plans can be shaped bit by bit to make the most of growing understanding (Dick, 2007). We use the synergy of both to take advantage of the emphasis on participation from the action research approach and the data analysis principles from grounded theory. Each cycle of the action research methodology was recorded and grounded theory methods of noting, coding and memoing were used to analyse the data afterwards.

Interesting topics and key factors were identified and influenced the planning of the next iteration (Glasser & Strauss, 2008). In between the various iterations one of the researchers was an active member of the knitting clubs, building trust relationships between researchers and participants. Later, in the weekly meetings, knitters reflected on their practices during open-structured interviews.

**Artefact Description**

As in knitting, rhythm in music is a key element. In order to translate the knitter’s expertise from the domain of material craftsmanship to that of sound, existing instruments were directly adapted to the particularities that characterise the choreographic nature of the activity of knitting. A drumming metal hi-hat, a directional microphone and a theremin were located in direct contact, right in front (2-5 cm) and 40 cm, respectively, from the needles. The sound output from each source would then be processed by a computer, either synthesising new sounds based on the knitting exercise, or influencing the output of the rest of the knittstruments performing at the same time (Image 1).
Participants
Participants belonged to two knitting clubs. All of them were women (approx. 40 in total) of varying ages. The focus group were professional knitters who had the flow of knitting and, at the same time, the possibility to transform their knowledge into music. All the members of the club that participated in the research are experienced knitters, working on different projects at the same time, with different techniques.

Environmental Setting
For the interactive nature and its impact on the knitting experience to be thoroughly explored, three creative scenes were designed: a cozy living room, the stage of a music club and a public space within a hall during an electronic music festival (DEFINE). These were located in the Danish town of Sønderborg, chosen to accommodate knitters (woman with an average age 60) and knittstruments to improvise onstage spontaneously creating a performance (Images 1-3).

Task
The main task was to make knitters aware of their bodily movements, by transforming knitting into sound. Musical instruments were the mediators of this transformation. Knitters had to compose music through their crafting practice with the help of musical instruments and digital technologies.

Data Analysis
Qualitative Analysis of Bodily Behaviour
From the first experiment the theremin proved to be a valuable bridge in translating every movement into sound, inviting the knitters to change their knitting routines. The instrument tracked every bodily movement (pulling the yarn, lifting the thread, moving the needles) and transformed it into sound (image 4).

Video motion analysis software was used to track the knitters’ sequences of actions. While experimenting with the theremin (software: PhysMo v2), selected frames were chosen to create an action sequence shot. The frames show how the different knitters tried to make sense of the audio feedback of the theremin, by moving their body accordingly.

Results
Improvisational Creativity Through Awareness of Epistemic Actions
Through the analysis of data an awareness of epistemic and pragmatic actions surfaced. According to Kirsh pragmatic actions are referring to those taken to implement a plan – in the context of knitting, to add stitches. By epistemic actions he is referring to all the actions that seem to bring the agent closer to the goal – pulling the yarns, shifting the needles. The knitter’s perception changes, in these transitional moments, between the previous and next action, which challenges their creativity during the process of making.

When the impact of their activity was not solely translated into a yarn but also a musical pattern, knitters tried to adjust their skills to the new setting in various ways, from rhythmically pulling the yarn, to altering the knitting angle (from a static horizon plane to the vertical one). Even employing their whole body to dance, or jokingly responding to the musical output of the knittstruments.

Knitters exaggerated their movements in their attempt to make sense of the audio output, shifting over from one side of the instrument to the other. In doing so knitters built upon their skills practices. The direct coupling between action and perception, through sound, brought them out of the flow state (Nakamura & Csikszentmihalyi, 2002), which let them experiment and, during the process, improvise with all the tools available (yarns, needles, sound, body).

Knitters Weave Melodies Out of the Flow State
Knitters were aware of the importance of their skills without necessarily being able to perform. While knitters were experimenting with their knitting
practices and the new setting, we identified physical tension, as their body was moving. They were experimenting, not only with their hands, but with their whole body, the selected yarn and the knitting sticks. Knitters left the state of flow and became present in the new activity. After the performance, informal talks documented that they really enjoyed that they could ‘sound’.

**Knitting is Communication and Participation**

Knitting implies social spaces and usually creates sites for conversation. This activity is usually accompanied by chatting among participants (Image 5). We observed that this was not the case when knitters faced the need to express themselves musically. Instead of creating a common knitting structure, the knitters created a musical pattern based on their bodily movements. Conversations were scarce and brief, which may be due to the increased demand for attention.

**Discussion**

The goal of the knittstruments was to explore how knitters can translate their embodied skills into new practices, by directing perception and action through auditory feedback. This research aimed to unlock alternative ways of creativity based on individuals’ embodied knowledge. An interesting topic emerging from the literature review, and the interviews conducted with the participants, is the meaning of creativity in knitting. Reflecting on this, two of the interviewers mentioned that in order to be creative, one has to have a lot of experience and ability to create one’s own patterns.

If you have done sufficient of these patterns then you start thinking this is not quite what I wanted to do. And then the more creative process starts. It’s not like when you are ten (years old). I am 48 and I have been knitting my whole life and still I am at the same level in the creative process, as this wonderful lady here. I am still lacking experience.

If you have done enough of these patterns then you start thinking this is not quite what I wanted to do. And then the more creative process starts. Now I am doing something creative, for example these patterns here. The idea of how to make a cape in this way I got from a designer, but I wanted to make my own pattern, although I am not so creative that I can construct my own. What I do, is I take patterns from other things. This is embroidery from 1760. Then I took a picture, and then I made my own knitting pattern. This is half-creative, because I am stealing patterns from everywhere.

Another interesting aspect of the project is that the potential collision of digital technologies with craft practices can reveal new design opportunities. Digital tools can unlock participants’ creativity based on improvisation during the process of a knitting piece, and may do so in other crafting practices.

There are various projects that represent the process of knitting and the rhythm of bodily movement, through visual or audio representations, but there is no link to creativity. The Movement Crafter (Pschetz et al., 2013) or Knitting Sound (Interaction Lab, 2014) are projects that aim for a physical representation of bodily movements. The visualisation presents a complementary output for the knitting activity.

In this research, we don’t see the body as the fence between the inner and the outer world, but as something in between. The main focus here is not on the patterns and their creation, but on the individual bodily rhythm and the body as a tool in use during the knitting process. Results from this research showed that the knitters’ awareness of their bodily movement affected their performance and enhanced creativity, based on improvisation during the process of knitting.

The knitters built upon their skill practices. The direct coupling between action and perception, through sound, brought them out of the flow state, and let them experiment and improvise during the process with all the tools available (yarns, needles, sound, body). In contrast to freestyle knitting, where improvisation lies on the free form of a knitting pattern and leads to a new pattern, here, every change of bodily position changed the sound output and triggered the next action.

One of our observations was that conversation among participants was scarce during their musical performance. The reason for this behaviour was not obvious, but we estimate that as every new skill activity requires a matter of practice, knitters have to familiarise themselves with the instruments to then be able to perform.
Reflecting on the artefacts that we selected to conduct the current research, the feedback we got from the audio output of the theremin was not so positive. A theremin is one of the most difficult instruments to play with and presents a lot of technical difficulties (Glinsky, 1992). While one hand controls the pitch and the other the volume, the distance between the two hands remains always around 50cm, whereas in knitting, the hands are in close proximity to each other. Transforming the knitting and the bodily patterns into harmonic sound with the combination of a theremin and digital filters is a challenge that design practitioners could take into consideration.

**Future Work**
The knittstruments are subjected to an ongoing process of modification in order to smooth the interaction between user and artefact, which is currently computer driven. Sensors are being deployed in the needles to reduce the separation between customary knitting and audio output and software alternatives (Max MSP as opposed to Ableton Live) are being explored.

The social interaction among knitters is also part of our future work. Current prototypes intend to improve the governance of the knittstruments, providing better global feedback among knitters in order to be able to compose sound together while working on their physical pieces alone.

An interesting application of the work presented in this paper is the possibility to transform other activities that rely on repetitive movements, such as physiotherapy, into creative activities.

**Conclusion**
The combination of action research and grounded theory helped us build the theory and the practice at the same time, based on the data that we collected. With this study we focused on a personalised way of knitting and the knowledge that the body has acquired through experience. Knitters became aware of their bodily movements, through the addition of audio feedback and started experimenting on their skill practices.

As a study of creative practice, our work presents a useful lens on knitters' creativity in the process of making. The study also questions the tools in use for knitting. We follow the notion of rhythmanalysis where the body is not simply analysed as a subject, but is used as the first point of analysis, the tool for subsequent investigations (Lefebvre, 2004).

Knitting needles, yarn, sound and the body itself, are the instruments of the knitting composition. This research gave an overview of how we can stimulate creativity in knitting. We focus on the process of making, the embodied knowledge of the knitters and the rhythm of the bodily movements. This study is not, for the most part, another attempt to visualise the bodily rhythm of knitters (Movement Craft, 2013; Knitting Sound, 2008), but an attempt to extend the knitters' creativity, through the awareness of their bodily movements.

In this paper, we explored the possibilities of coupling the methodical activity of knitting and that of audio generation. Three different instruments (knittstruments) served as a tool to bridge the gap between merely producing a yarn pattern and generating an audio output. The behaviour of the knitters while performing in three different designed stages, as well as the shift in the perception of their accustomed working tool (knitting needles as tools for sonic composition), opens up new design possibilities.

**References**

Konstantia Koulidou is a design researcher intrigued by how craft practices and digital technologies and fabrications can open alternatives ways of self-expression and connectivity. She has recently graduated from IT Product Design from Southern Denmark University with design experiments in musical knitting, wearable probes, and previous training in both architecture and jewellery. Understanding how people feel and experience a situation is an important part of her design practice and she is engaged in a personal dialogue with her participants. She just started her PhD in Digital Jewellery at Northumbria University and her current interest lies in understandings of new ways in which digital worn artefacts can support a wearer’s sense of self and contain personal meaning.

Enrique Encinas is delighted to misunderstand the boundaries between the self, the body, the technology, objects and others. Trained as an engineer in Spain and Taiwan, he is currently a 2nd year student in the MSc program of IT Product Design at Southern Denmark University, where he enjoys connecting (or inventing and destroying) the dots when it comes to interaction and participation within design practice. He respects bits and electrons as much as the ideas of Merleau Ponty, Alfred N. Whitehead, Vilém Flusser, John Dewey or Tim Ingold, for they are quietly (and loudly!) present in his prototypes.
Community Making & Making Communities:
Crafting non/digital interactions

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CARE, which stands for ‘Community Asset-based Research and Enterprise’, is a research project funded by the Arts & Humanities Research Council’s Connected Communities Programme. It brought together an interdisciplinary team of academics, practitioners and community researchers to work collaboratively with hobbycraft (amateur or voluntary) groups. The aim was to test and develop a methodology for co-produced community learning through creative practice, skill-sharing and storytelling to build confidence and promote self-reflection and reflexivity. We wanted to explore how craft knowledge might be applied through processes of co-design (engaging all stakeholders), co-creation (collaborative work) and co-discovery (by formal and informal researchers). The project worked with community groups and partners in Cornwall, Birmingham and Dublin and used participatory action research methods in digital fabrication, virtual communication, and face-to-face activities and workshops. Co-creating CARE was a big project, but not a digitally-based or focused one. In the context of the All Makers Now? conference we will discuss why we were impelled or moved towards including digital elements, what these elements were, and their effect on the project.

Creative hobbies are a fertile ground for exploration: millions engage in them each year. Activities such as knitting, crochet, embroidery, woodworking, metalwork, photography, quilting, lace-making, basket making, beadwork, model making and weaving, for instance, are undertaken voluntarily for pleasure and involve high levels of ingenuity, competence and creativity. Hobbies are particularly valuable for this project because they represent an important area of community asset and strength: skills, knowledge, expertise and capabilities that are often devalued or dismissed (Hackney, 2013a). This paper draws on research from the AHRC-funded project Co-creating CARE (Community Asset-based Research and Enterprise), which explores how crafts knowledge might be applied through processes of co-design (engaging all stakeholders), co-creation (collaborative work) and co-discovery (by formal and informal researchers). The project works with community groups and partners in Cornwall, Birmingham and Dublin and uses participatory action research methods in digital fabrication, virtual communication, and face-to-face activities and workshops.

CARE initially aimed to explore how craft might work as a bridging activity, bringing disparate groups together to enhance social capital. A series of short films were made to explore intergenerational skill sharing through creative making (Hackney, 2013b). These demonstrated how film can communicate crafts in community settings; the activity also revealed the power relationships embedded in creative exchange, as tensions emerged around, for instance, digital making, suggesting important questions about the future of traditional skills and how these might be productively combined with new technologies (Maughan, 2014). To find out more about collective sharing through making, research took what we term a ‘material consequences’ approach, embracing playfulness and risk. Participating groups were asked to collaboratively devise ways to capture and reflect on the ‘small stories’ of collaborative interaction through making. The resulting research ‘texts’ (a digital sharing platform, a sewing box of embroidered ethnographies (stitched stories and interactions) and a digital fabrication workshop) embody and materialise a narrative of co-discovery as groups address the value of learning and through sharing and making, digitally and otherwise, and reflect on how this knowledge might be applied in other aspects of their lives.

Abstract

Millions engage in creative handicrafts, activities that are undertaken voluntarily for pleasure and involve high levels of competence and creativity, representing an important area of community asset that is often devalued or dismissed (Hackney, 2013a). This paper draws on research from the AHRC-funded project Co-creating CARE (Community Asset-based Research and Enterprise), which explores how crafts knowledge might be applied through processes of co-design (engaging all stakeholders), co-creation (collaborative work) and co-discovery (by formal and informal researchers). The project works with community groups and partners in Cornwall, Birmingham and Dublin and uses participatory action research methods in digital fabrication, virtual communication, and face-to-face activities and workshops.

CARE initially aimed to explore how craft might work as a bridging activity, bringing disparate groups together to enhance social capital. A series of short films were made to explore intergenerational skill sharing through creative making (Hackney, 2013b). These demonstrated how film can communicate crafts in community settings; the activity also revealed the power relationships embedded in creative exchange, as tensions emerged around, for instance, digital making, suggesting important questions about the future of traditional skills and how these might be productively combined with new technologies (Maughan, 2014). To find out more about collective sharing through making, research took what we term a ‘material consequences’ approach, embracing playfulness and risk. Participating groups were asked to collaboratively devise ways to capture and reflect on the ‘small stories’ of collaborative interaction through making. The resulting research ‘texts’ (a digital sharing platform, a sewing box of embroidered ethnographies (stitched stories and interactions) and a digital fabrication workshop) embody and materialise a narrative of co-discovery as groups address the value of learning and through sharing and making, digitally and otherwise, and reflect on how this knowledge might be applied in other aspects of their lives.

Keywords: Co-design, community, stitch.
However, the activity also revealed the power film can communicate crafts in community settings. We used a series of short films exploring this community partner, Craftspace. During this phase we paired older craft makers with students from each local area in Falmouth, and in Birmingham via our networks. We wanted to understand what extent can craft help us cooperate? True cooperation is a difficult, demanding process; a fraught, ambiguous zone of experience where skill and competence encounter resistance and intractable difference (Sennett, 2012). This echoes Gilchrist’s (2000) notion of an intermediate zone of ‘untidy making’ and captures some of the tensions experienced in our phase one buddy exchanges. Participants’ different notions of creative making alternately clashed or found grounds for compromise. Sennett (2012) argues that exchanges of difference (what he terms ‘dialogic cooperation’) or the location of common ground (‘dialectic cooperation’) or, most often, a combination of the two, are necessary to achieve knitted together interactions. He contends that the key is to respond to others on their own terms. This involves such skills as the ability to listen well, behave tactfully, find points of agreement, and manage disagreement and frustration. Our question became - to what extent can craft help us cooperate?

In the initial part of the project, phase one, we paired older craft makers with students from each local area in Falmouth, and in Birmingham via our community partner, Craftspace. During this phase we used a series of short films exploring this intergenerational skill sharing through creative making (Hackney, 2013b). These demonstrated how film can communicate crafts in community settings. However, the activity also revealed the power relationships embedded in creative exchange, as tensions emerged around, for instance, digital making, suggesting important questions about the future of traditional skills and how these might be productively combined with new technologies. Hannah Maughan was Practice Researcher and was buddied up with Barbara, a member of the local branch of the West Country Embroiderers. Barbara is a self-taught and phenomenally talented technical maker who is particularly interested in traditional embroidery. Barbara, who volunteered to be part of the project, was invited to fill a shoebox with objects which expressed herself and her craft. As the recipient, Hannah’s task was to creatively respond to the contents of the box alongside a short film of Barbara in her home, speaking about her practice. Hannah responded to the task in this way:

The box contained all the ingredients of a Mountmellick embroidery kit which Barbara had carefully put together, including thread, fabric (with a hand drawn outline of a motif), A4 instruction leaflet and a photograph of the finished piece of work (Barbara’s I assume).

Barbara had gifted me a mini project in itself. It suggested step by step learning, the passing on of knowledge and skill, all of which greatly appeals to me. It created an instant link between us, my way of thinking and teaching and Barbara’s experience of her embroidery group and how she approaches her craft and learning. However, my initial response was that it would be far too easy for me to take up the kit, complete it and be done with it, and in this sense I wondered if that was what Barbara expected. Instead, I tuned into the film and was fascinated by both the words and the work that featured. The film was far more personal and gave a stronger insight into Barbara. What stood out to me was the traditional bobbin Honiton lace work that Barbara painstakingly and beautifully produces by hand; a true labour of love and evident personal passion. I had for some time been looking for an opportunity to explore ways to investigate making lace digitally and saw this as an opening.

In the Textiles Design studio at Falmouth we have a small single head digital embroidery machine, currently run through Aps-Ethos software. My CAD skills are limited though I have some rudimentary knowledge and experience of this particular programme. I had four days in which to create a body of work for this project and chose to centre my research on the pre-programmed stitch structures available in the software. Within the program settings I selected gridded stitch structures that appeared lace-like and which echoed those of Honiton lace. I began by simply stitching them in a square form onto a range of dissolvable base fabrics. I didn’t know if the structures, which on screen...
appeared to be interconnected, were actually so, and was keen to see through trial and error what would happen, what worked and what didn't, once the base cloth was removed to leave just the thread.

Initially what I thought I was aiming for was for the structures to remain intact once the base fabric dissolved and for most this did happen. At times the visual appearance of the structure would alter through the dissolving process, with the crisp, geometric definition becoming softer, more organic like and delicate once the base support disappeared, altering the tension. Others seemed to be more robust and retain their original identity. Different methods of how to dissolve the fabric impacted on it. Direct water pressure from the tap was too powerful and quickly destroyed the structure, whereas leaving the pieces to gently dissolve in dishes of shallow water worked better to preserve the shape.

However, not all the structures worked as I had intended, but rather than failing, these mistakes make opportunities. Some of the structures completely fell apart once the base cloth dissolved, leaving, for all intents and purposes, a long strand of thread. But through the process of digital stitching, a texture had been created transforming the thread and suddenly ideas began to evolve of using this digital thread to hand stitch with. For some structures connections remained at certain points fringes. Exploring the scale of the structures, type of thread, (thicker wool and glow-in-the-dark), offered further variations, before considering how to create alternative shapes with the structures and methods of joining different structures together.

At the same time, I was also involved in a research project with the Learning Futures department at Falmouth. We were investigating the use of the iPad within the practise based, studio teaching environment and I saw this as an opportunity to challenge myself to create and document the entire CARE project through the iPad, further underpinning my use of digital technologies. The portability of the iPad made research into and communication of the project immediate and accessible via the internet whilst using it to take videos and photographs allowed me to easily record the stages of the project. I could directly upload the photographs, add web links, make notes and drawings through the Bamboo Paper app which acted as my digital sketchbook. At times the process was hampered, with software glitches and frustrations in exporting the sketchbook from the iPad to share with others; however the overall benefits were favourable.

I presented the project to Barbara, meeting face-to-face for the first time since we had been buddied up. The iPad made for effective sharing and the focus of my four days' work coupled with the speed of the digital embroidery process meant that I had a good range of samples to show. Although Barbara was certainly interested in my response to her offerings, the direction I had taken and the work produced, recognising in me that shared commitment and passion for embroidery, it was apparent that she was perhaps bemused by my investigation into lace digital. For her the two words, digital and lace, were polar opposites.

The question continually arose as to whether or not the use of the digital in lacemaking was 'cheating', a term we both used during the discussion. The sense of being physically 'hands off' from the making with the machine doing the stitching was an issue that was hotly debated, as was the speed of the process. Where was the skill in pressing a button? Did the work have as much value? Does the craftsmanship instead become imbedded into the knowledge of and creative application of the software? But it was recognising that this is an alternative method of working, offering something different both technically and visually rather than trying to mimic or replace the traditional aesthetic and skill of bobbin lace.

Although the buddy scheme included the opportunity for further skill swapping, Barbara made it clear that she was not interested in engaging personally with the digital in any way. Nor was she interested in alternative suggestions of learning from me, being firm in her own identity and position as a maker. For my part, this was a big and unexpected learning curve of the project. Initially it confused me as I consider any chance to work with others, to learn, to question and to push the boundaries of embroidery and design as opportunities and commonplace. What Barbara taught me through her reaction was that for some, embroidery is what it is, you do it a certain way because that is how it is, you use a certain type of thread because that is what you are supposed to use. Honiton lace can’t be done in colour because traditionally it’s white. Perhaps there was a certain amount of fear, lack of confidence or stubbornness in her unwillingness to engage. However, for whatever reasons, I now respect the decision and recognise it is as valid as my own approach. We are united in a common passion for the craft whilst appreciating that the value of embroidery and making means different things to different people and there is a place for all of us.

Exhibiting the digital lace samples at the AHRC Connecting Communities conference in Edinburgh, in July 2013, a similar reaction against the digital played out again. Laid out on the stand, the work attracted interest and people were encouraged to
In order to examine the findings from phase one of the project we organised a day event aimed at sharing experiences and thinking about further directions in which the groups from Falmouth and Birmingham met and shared experiences. It became clear that, as well as the digital/other conflict already mentioned, there was an interesting disparity surrounding the difference between those who had met before any crafted material had been exchanged, and those for whom the materials or objects were the first point of communication. The day led to a development of a series of research questions for shaping the second phase of the project.

These research questions included:
- To what extent and how does the CARE method of collaborative learning through sharing, making and reflecting offer a means to build on and develop community assets, strengths, skills and creativity?
- If so how can this best be facilitated and supported? To what extent can groups self-support?
- To what extent and how do groups feel ownership over their work?
- How are the power relations in groups manifest? And how are any tensions, or differences of opinion experienced, managed or resolved?
- Can we characterise the nature of the exchanges that take place during the CARE process? To what extent do they represent dialectic (the location of common ground) and/or dialogic (exchanges of difference) modes of engagement, and how might this be mapped onto processes of talking and making together?
- What is the relationship between online and offline interactions and digital processes within the CARE process, and what are the strengths and weaknesses of each?
- To what extent do established local community (regional) identities change/transform/remain unchanged, or strengthen, after contact with others located in geographically and/or culturally different contexts?
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In order to engage with these research questions, alongside other actions, such as mediated and self-organised crafting groups, three main digitally-based or influenced research texts were developed: a digital sharing platform, a sewing box of embroidered ethnographies (stitched stories and interactions) and a digital fabrication workshop.

Firstly, we will consider the digital sharing platform that we called Making Things Together. The idea for this arose out of the area of discomfort that some participants had expressed about one-way exchanges in the first phase: the older participants had handed on a shoebox of materials and thoughts and the younger participants responded to this. That is where the iterations finished and some of the younger participants felt that they had not been as respected or their work engaged with as much because of the lack of reciprocal response. We wanted to examine a more extended series of iterations to see how communication, of itself and via the medium of craft, developed. We were also responding to the differences expressed in the phase one sharing event where discussions around whether meeting the buddy before handing over the shoebox – or not – altered the partner’s response to the craft items or processes. We took, what we term a ‘material consequences’ approach, embracing playfulness and risk, using a digital tool a bit like Facebook, in which communications could be both public, to the entire group, and private, because we wanted people to set up ‘buddying’ partnerships, where they communicated via craft with one other person through a series of exchanges. What we were looking for from the digital tool was to capture and reflect on the small stories of collaborative interaction through making, as well as being an easy and fun way to participate in what we ended up calling craft pen friends.

Initially, we made some good progress on this idea and progressed quite a long way towards being able to capture the small stories alongside larger exchanges, and seeing if communicating with craft as a focus had a different quality even online, as it seems to in person. However, we did not manage to iron out all the glitches in the online tool: some people found it difficult to join up, and we lost keen participants at this first hurdle. Some found the tool not as inspiring or engaging or intuitive as they had hoped. Some people just found they had become too busy and were not as committed as if they had been meeting. Though we had expected to lose some people in this way, we think the main reason the online tool did not take off is that it just did not reach critical mass. There were, as one of our advisors put it, ‘not enough people on the dance floor’. For this reason, and because we think the idea has a lot to recommend it and some interesting research possibilities still to explore, we are intending to develop more research around the idea of the online crafting sharing platform. Even though this digital strand was not what we would call successful in this iteration, we hope to explore it further.

A much more successful digital exploration was Hannah’s embroidered ethnography group:

“In the second phase of the project I set up my own stitch group. This time I decided to focus on working...
with like-minded people and to explore the positives of this community, such as sharing interests, swapping skills, learning together and the support and encouragement all of this would offer. The emphasis of the group was on the professional as opposed to the amateur maker and was comprised of a number of my mixed media graduates who had stayed in Falmouth post degree. I was aware of the need for such a group, having had numerous conversations about the loss of community and lack of direction and motivation that graduates often experience as self-employed practitioners. Six in total and spanning the years, not everyone knew each other but friendships quickly and easily formed through the common connection of me, embroidery and the degree.

Over the three months that we met, much was debated in terms of the current embroidery and education landscape and the impact the digital age has had on it. We would often use YouTube videos to learn new techniques, watch webinars of other embroidery designers discussing their practise, link to on-line stitch communities and share favourite websites with each other. The pros and cons of Pinterest were discussed at length; full of accessible and unlimited inspiration or sticky in terms of IP and copyright infringement, easy to collate and share or a lazy way to research – the group was divided. The use of social media and on-line profiles were seen as essential tools to connect professionally and market business. During the sessions we would text, share links and send photographs with group members who weren’t there, keeping them directly in the loop and I regularly blogged about each session on the main CARE website, which connected us to the other groups within the wider project. Digital embroidery was viewed as an area ripe for development with few having practical experience of it, and the possibilities and potential to creatively explore both the software and the machine interface appealed to all.

Set against this digital backdrop was the hands on making. Conversations would ebb and flow as we lost ourselves to our stitching. The work I produced from the sessions began to reflect these conversations, the small stories of making, selecting out words and phrases that I stitched back into the context of our making, creating an embroidery toolkit, making tape measures, needlecase, pin cushion, some of which was done by hand, and some by digital means.

The groups we engaged with in Birmingham and Dublin were involved in digital technology by way of crafting using the Makernow FabLab as part of their reinterpretation of local landmark heritage sites. This combination of heritage and the digital became one of the most fascinating aspects of the project.

In Dublin, participants were approached via community partner Bealtaine, an Age & Opportunity initiative part-funded by the Arts Council and delivered by hundreds of organisations around Ireland (local authorities, arts centres, libraries, Active Retirement groups, care settings, community groups and clubs). Over 120,000 people now take part in activities ranging from dance to cinema, painting to theatre. Bealtaine utilises the talents and creativity of both first-time and professional older artists from every part of the country to run events that celebrate creativity as we age. This is a major reason we initially focused on inter-generational sharing of skills in phase one of the project. Though this became less of a focus in phase two, we retained Bealtaine’s group connections, and particularly those with which our Birmingham community partner, Craftspace, already had working links and connections.

Craftspace is a crafts development organisation exploring crafts in diverse cultural and social settings, working nationally and internationally to build relationships between artists, people and organisations through a programme of touring exhibitions, research and participatory projects. Their work is ‘supportive and developmental, enabling the sharing of skills and knowledge. Artists, participants and partners are involved in planning, development, collaboration, documentation and reflection’ (Craftspace, 2014).

The link with Craftspace was pivotal in finding participants and in developing the co-creation and co-reflection elements necessary for the development of the project. Craftspace was already working with Bealtaine with a group of crafters using Rathfarnham Castle in Dublin as a meeting space and as a source of design inspiration for art work they were producing.

Craftspace decided to use the same approach in Birmingham, and recruited a group of crafters who used Soho House as a stimulus for creative work. Both groups worked with artists to develop designs, and sent these prototype designs to the Makernow lab, receiving their created designs back again to redevelop and rework.

One of the most successful parts of the project was a trip that both Dublin and Birmingham participants had the opportunity to take part in. A few community crafters from each place, along with the lead artists, came to the Makernow lab to see the process of turning their designs into finished constructed items. This, alongside the skilled and experienced input from the Makernow team, led to some excellent outcomes.

One of the most important of these was the quality of reflection on the process and the products from the group participants:

[the] reflection on outcomes was…significantly enhanced by the expert designing, making and leadership skills of the experienced artists in the group, enabling discovery, discussion and design thinking to develop through the process of sampling and prototyping. Being together as a group in the
same space was vital for this and was reinforced by the digital and traditional design-making knowledge of the Makernow team. (Bunnell, 2014)

Subsequently the designs have been developed and Soho House plans to sell some of the products in the museum shop. This was not an output which was planned from the start and indicates a development in the idea of the project, at least a direction in which following outputs could be advanced. Another potential direction is to find a way of providing software training and support for the community artists and participants so that the rest of the group could be helped to develop their digital design work. But this is a digital aspect of the CARE project which was extremely successful, in terms of outputs, co-reflection and co-discovery.

The CARE project is now finished but has thrown up some interesting directions in which the interest in craft, co-design, social engagement, and the digital could be developed. Initially there is a link with projects to do with health and well-being, with crafters from Falmouth continuing to meet as they began to do in phase two of CARE, but focusing on the benefits of crafting to health and well-being. Other aspects may be developed in subsequent projects, in which groups continue to explore tensions and opportunities for collaboration and co-production and address the value of learning through sharing and making, digitally and otherwise. We have found that, just as the boundary between voluntary/amateur and professional are contingent and shifting, so the supposed solid divide between digital and non-digital is similarly unconstant and fluid. Though initial responses to the digital element in craft can be polarised and polarising, experience and familiarity can help crafters create and cultivate a narrative of co-discovery as groups and individuals, and consider how this knowledge might be applied in other aspects of their lives.

References:

Mary Loveday Edwards is a writer, researcher, performer and academic. She has a BA in Theatre with Performance Writing and an MA in Arts & Ecology. Her practice focuses on ideas around nostalgia, belonging, belief, ethics, and ecology. She writes and performs both solo and in collaboration with others. She has built and rigged puppets and worked at departments for television, and worked as props and costume maker for theatre. She has written on craft, art and pedagogy for international journals, conferences and exhibitions.

Hannah Maughan was trained at the RCA and works as a freelance textile designer, specialising in embroidery and mixed media. Clients include Christian Lacroix, English Eccentrics, United Arrows, Byblos, Joseph and Habitat. Since 2003 she has also worked as Senior Lecturer on the BA (Hons) Textile Design programme, establishing the mixed media area. This focuses on engaging the students in the traditions and values of hand and machine stitch and fabric manipulation but with the emphasis on technical acumen and creative response to personalise and contemporate the discipline.
The Engraver's Bench
As with all skilled trades, engravers have long since made use of available tools and techniques developed to reduce the demands on their dexterity. Compasses, ink and paper are used to mark out a job. Sandbags and clamps conveniently secure work. An engraver's traditional cutting tools, their gravers, have sharp tips that are variously shaped, inclining them to travel in a favourable direction for different types of cut. For centuries, even before the advent of powered mechanisation, the engraver's bench has been home to an assortment of tools, both specialist and common, which have been employed to improve the precision and efficiency of the trade.

The adoption of each new tool brings a reconfiguration of the engraving trade as it adapts to the potentials of new techniques. No doubt the introduction of electric task lights, allowing practitioners to work at any hour, sharply illuminating any imprecision in their work, had a dramatic impact on an engraver's practice. With the advent of digitally controlled engraving, we argue that the newest techniques are simply a continuation of this history, another step in the development of the craft, and there is no need to lament any loss of skill. In fact, the development of digital tools has forced engravers to develop new skills, similar to those of digital typographers and machinists.

Of course, these skills are different in nature to the manually dexterous action required for hand engraving. And some might argue that trades, such as engraving, are weakened through this technological deskilling or, perhaps more accurately, re-skilling. This is not, however, our line of argument. Our concern is not for the skill of hand engraving, but the knowledge of best practice that is learned alongside dexterous action.

Our position is founded on three observations:

1. That any theoretical distinctions between ‘handwork’ and ‘machine work’ are difficult to sustain.
2. That there exists a body of communicable knowledge about a craft’s best practice, which helps to both create and define notions of quality in that craft.
3. That this knowledge of best practice can and should be better supported through more considered software development.

Abstract
Engraving is one of the oldest arts. For thousands of years, people have embellished the surfaces of caves, tools, buildings and armour, using hard materials to make marks in softer ones. Whilst crudely incised love hearts on a tree bark or names on bus windows can be carved with little practice, to cut precise lines requires the skill of an experienced practitioner. Engraving has, therefore, long been practiced as a specialist trade across cultures. More recently, powered rotary cutters, machines that can trace a predetermined path with a greater degree of accuracy, have supplemented the tools and techniques of hand cut engraving. Today, data from digital files guides rotating bits or laser beams across flat materials, cutting or burning designs into a wide variety of woods, metals and plastics.

In this paper, we describe a piece of software developed to support the use of traditionally derived engraving patterns in digital design work. Placing this software in the context of a constantly developing skilled trade, we see no need to lament the loss of skill often associated with advances in mechanisation. We argue that as the transition between a design and its material realisation becomes increasingly digitised, sensitivity to the existing best practices and guiding principles of a trade must be carefully supported in our tools and the software that drives them. In the case of engraving, these practices and principles are the result of thousands of years of work, presenting a rich history of knowledge that might easily be lost in the gaps between the cobbled together hardware and software of digital fabrication labs.

Keywords: Engraving; software development; craftsmanship.
In this paper, we explore these themes, before describing a piece of software developed to support the use of traditional hatching patterns in digital engraving.

**Hand & Machine Work**

In the context of a skilled trade, to discuss the relative virtues of engraving by hand or machine, as if they are somehow opposed, is to begin on a path fraught with what design and craft theorist David Pye would call ‘thought preventers’ (1972, p.52). In his attempt to bring a logical clarity to matters of craftsmanship, Pye explored what is meant by the phrase ‘hand made,’ observing that, except perhaps in a few examples, such as the making of coil pots or basketry, all manufacturing techniques require the use of tools (ibid, pp.25-29). And these tools, owing to their design, and in the context of skilled use, invariably aid the hand, enabling more consistent results.

One of the first tasks a novice engraver learns is how to sharpen a graver, so that it may cut a smooth, clean line with control. As soon as this newly sharpened tip cuts into a surface, its path is guided not just by the hand, but by the whole system of hand, graver and material. The tendency for a tool like a graver to move through material in a particular way, led Pye to dismiss the idea of ‘hand work’ and the ‘handmade’ object as ‘all but meaningless’ (ibid, p.25). Considering the similar propensity of a woodworker’s chisels to ‘cut their own jig’ (ibid, p.28) as they enter a piece of wood, Pye showed that even seemingly unaided tool use is, in fact, nearly always guided in some sense by a determining system.

To discuss hand engraving and machine engraving then, whilst a useful shorthand, we must accept that wherever our work with materials is mediated through tools, those tools also guide the work. Using Pye’s terminology, the variously risky or certain (ibid, p.20) techniques of making cannot be placed into the preferred technique.

These new techniques have demanded that new skills be assimilated into the engraving trade. In contrast to the popular notion of technology as a deskilling force, engravers have been forced to develop new talents, manipulating hardware and software, working simultaneously as digital typographers and machinists.

For anthropologist of technology François Sigaut, the engraving trade would certainly conform to his ‘law of the irreducibility of skills’, under which the ‘the entire history of technics might be interpreted as a constantly renewed attempt to build skills into machines by means of algorithms, an attempt (that) constantly failed because other skills always tend to develop around the new machines.’ (1994, p.446)

Sigaut’s law assures us that there is no call to lament the loss of skill often associated with new techniques – skilled practice will always remain vital for human work. As the engraver’s hand retreats from holding the graver, to tracing the master pattern on a pantograph, to clicking a mouse and pressing go, the demands on manual dexterity certainly decrease, but, at the same time, novel tools and techniques require new skills that must be assimilated into the trade.

**Best Practice**

We have, thus far, considered the mechanical skill of engraving, the dexterity with which a hand or computer-controlled tool can be manoeuvred during a job. We now go on to discuss how the rules and principles of best practice support this action. To understand engraving just in terms of mechanical skill that can, and has been, codified into machines by means of algorithms would be to ignore the body of associated communicable knowledge that is developed and shared in practicing a trade. It is this knowledge, not the dexterity of engraving, that we argue is most at risk in the typical processes of digital engraving.

Within a craft, ‘best practice’ is guided by a set of foundational principles and rules. An insightful discussion of the nature of best practice can be found in Janet and Charles Keller’s anthropological study of expert artist-blacksmiths (Keller & Keller, 1996). Keller & Keller identify three guiding principles used during a blacksmith’s practice: ‘transformation’; ‘think hot’; and ‘work freehand’ (ibid, pp.52-58). These three principles are relied upon to influence and guide the blacksmith’s work.

The principle of ‘transformation’ dictates the nature of the processes used when blacksmithing: rather than add or remove material, by welding or filing the iron, blacksmiths are inclined to change the shape of their material without addition or subtraction. Transformative processes, such as folding and twisting are therefore the basis for much work. By ‘thinking hot’, blacksmiths are encouraged to exploit the plasticity of iron at high temperature. Cold forming processes, such as drilling a hole rather than punching it whilst the iron is hot, are avoided. The final principle, ‘work freehand’, encourages blacksmiths to rely on only a very limited range of jigs and templates: the
Throughout practice, guiding principles provide a set of criteria with which to discriminate between different approaches to a blacksmithing job, underpinning every design drawing, material selection and hammer blow. It is their adherence to such principles that helps artist blacksmiths give ‘life to the ironwork’ (ibid., p.53), completely transforming the surface texture and form of stock material.

This idea, that principles continuously guide an expert’s practice, is at odds with the popular notion of skilled expertise as somehow unconscious. Although prompts, such as ‘mirror, signal, manoeuvre’, are well known to help novices learning new skills, the idea that mental rehearsal no longer plays a role in expert performance is often taken to indicate that skills become automatic with practice (Dreyfus, 1990).

Anthropologist Tim Ingold, however, criticizes the assumption that, during expert practice ‘awareness intervenes only to interrupt the otherwise automatic and involuntary flow of habitual action’ (2011, p.61), instead observing that the critical aspect of any skill is its continual attendance to ever changing environmental conditions (see also Bernstein, 1996).

This awareness and attendance, Ingold claims, only deepens with fluency and experience. The expert blacksmith’s hammer blow, or the well-practiced engraver’s cut, are not mechanically repeated, but respond to the variable plasticity and hardness of their materials, and to the emerging qualities of their work.

As in the example of artist-blacksmiths, these responses are continuously tuned with reference to their knowledge and understanding of best practice. Philosopher Andy Clark also insists that, whilst some linguistic prompts may no longer be required by experienced practitioners, ‘high-level concerns or policies’ (1997, p.203) are still relied upon in the pursuit of skilful work. Maxims like the blacksmith’s ‘transformation’, ‘think hot’ and ‘work freehand’ are examples of how such high-level concerns constantly influence performance. These are not principles reserved for reference only when novel challenges interrupt habitual practice, but an underlying guide for all action.

It is here that we might find a more meaningful distinction than the opposition of hand and machine work dismissed above. Perhaps the critical difference between hand engraving, wherein the explicit, communicable principles of best practice and their dexterous execution are tightly bound, and mechanised digital engraving, is in the latter’s division of designing from its material realisation. To design things on a screen and then execute them afterwards presents an interruption that does not exist in direct hand engraving. We acknowledge that such a significant theoretical and practical divide, between designing and making, cannot be bridged simply by means of different software. It’s a divide that rests at the foundation of modern Western understandings of production (Deleuze & Guattari, 2004, pp. 409-412; Ingold, 2013), and is strongly reinforced by the techniques and processes of digital production. The piece of software we introduce below, however, is an attempt to support at least some of the best practice of engraving; although not continuously throughout its material execution, the aim is to introduce these principles throughout the making of a digital design.

The question of why such an attempt, to take the traditional principles of best practice and apply them in the context of digital production, is valuable requires us to explore the nature of quality and connoisseurship in a craft. For those who, as Peter Dormer describes, have gone ‘native’ in a craft (1994, p.44), it is clear that the rules of best practice have not been developed and shared for their own sake, or, as might be assumed, out of a traditionalist adherence to the old ways, but because they help lead towards outcomes with certain favourable qualities.

As we have seen in the example of artist-blacksmiths, adherence to the three principles helps to give ‘life to the ironwork’. And, whilst such metaphorical qualities might appear obscure to the uninitiated, Dormer observes that, within the practice of a craft, these are criteria of quality that are judgments not ‘made on a whim’, but with a basis in objectivity (ibid.).

Through his own experience of learning calligraphy, Dormer describes how, with time and practice, he came to distinguish between the ‘rightness and wrongness’ (ibid., p.47) of letter forms with a degree of objectivity. The objectivity with which such judgements of quality are made, and the appreciation of qualities that follow from the rules and principles of best practice, this is what Dormer calls the connoisseurship of a craft. It is this that we fear may be lost in the typical processes of digital engraving.

Whilst the notion of connoisseurship might often be associated with exclusivity, the basic rules and principles of practice are not as mysterious as an outsider might assume, and may be found in the vast literature of how-to guides supporting the continuation and development of skilled trades. Our work is inspired by this literature. In the case of engraving, whilst offering advice on the development of an engraver’s hand skill, practical guide books such as Engraving on Precious Metals (Brittain, Wolpert, & Morton, 1958), also articulate a knowledge of best practice that sits alongside the dexterity developed through training.

In engraving, there is a right and wrong way to do things. There is, for example, a correct way to order the cuts, or strokes, of lettering (ibid., p.61); a correct way to contrast the brightness of a cut (which is increased by polishing the graver tip) with the surrounding material (ibid., pp. 83-84); and, particular to the engraving of heraldry, a correct way to use hatching patterns to represent specific colours (ibid., p.32). This is a subject to which we return when describing the Petra Sancta script. In the pursuit of good work, these ideas inform...
practice at every stage, step-by-step, helping to ensure that each job meets the required criteria of quality.

These criteria are, of course, open to question. And no doubt they have been debated through the practice of engraving throughout centuries of development. In a classic discussion on the nature of making in traditional societies, Christopher Alexander considers the development of traditional forms to be the result of sequences of decisions, made over generations (1964).

In such a system, ill-fitting forms are easily identified and improved, as seen in Alexander’s architectural examples, where the makers of buildings not only build them, but also live in them. Here, there is a direct, on-going relationship between failure and correction, such that traditional forms will always tend towards good fit: ‘misfit provides an incentive to change; good fit provides none’ (ibid., p.50), writes Alexander.

Key to this understanding is the idea that recognising bad fit is a relatively simple task that is within the capacity of most people. As the activity of building, making, or dwelling proceeds, flaws in the work are easily identified and rectified. The revisions made in response might eventually be incorporated into the broader practices of a tradition.

Alexander contrasts this process of gradual adaptation, influenced by the commonplace intuition that something is wrong, with what he terms the ‘self-conscious’ process of more recent design activity (ibid., pp. 55-72). Whereas the ability to spot bad fit might be widely distributed, the self-conscious process requires us ‘to achieve in a few hours at the drawing board what once took centuries of adaptation and development, to invent a form suddenly which clearly fits its context’. A situation wherein, according to Alexander, ‘the extent of invention necessary is beyond the average designer’ (ibid., p.59). Alexander’s observations should perhaps be tempered with reference to his broader condemnation of modern architectural practice and its ‘limelight-bound architects’ (ibid., p.57), but they offer a valuable insight into how and why the traditions, best practices and guiding principles of a craft come into being.

In the context of digital engraving then, we suggest that, wherever possible, better efforts should be made to support the shared, explicit knowledge of the trade in the software. If, as the title of this conference suggests, increasing access to digitally controlled manufacturing techniques, means we are all makers now; it follows that, more specifically, when incising acrylic, metal or wood, we are also all engravers. Our work is an effort to draw upon the wealth of knowledge that has been developed throughout the long history of engraving, and use it to support contemporary digital practice.

The Petra Sancta Script

The Petra Sancta script is a piece of software that we have developed. It allows practitioners to automatically hatch areas of an engraving design, converting the solid colours of vector graphics software to the traditional patterns of engraving, with reference to the ‘Petra Sancta’ system.

Published in the 1630s by Silvester Petra Sancta, the Petra Sancta convention for heraldic engraving remains the recognised standard for translating colours into engraved patterns. The system defines hatching patterns for nine colours (Image 1), providing legibility and contrast with one another. Although still in widespread use, the Petra Sancta convention represents an instance where, as the mechanical skill of engraving has been codified into digital hardware, an associated body of knowledge has remained unsupported in the software: how many practitioners raster engraving with a laser cutter in the typical digital fabrication lab, for example, are even aware of such a convention?

The problem with using digital graphics software to design for engraving is that it is almost exclusively developed with print or on-screen outputs in mind. Whilst dedicated engraving software does exist, its adoption is limited by the broad availability of more versatile programs that, paired with drivers to link them to engraving machines, can offer all the features of engraving-specific applications. And, because of the cross-program compatibility of vector file types (e.g., .ai; .pdf; .eps, and those other formats which may be used to drive engraving hardware) practitioners designing for rotary or laser engravers may choose from a wide range of vector graphics software.

Typically then, those applications that are most widespread, popular and well supported by both their authors and networks of users online are used to generate engraving designs. One such program, which is widely recognised as the industry standard vector graphics software, and serves as the test bed for the Petra Sancta script, is Adobe Illustrator (Illustrator).

Illustrator is an application developed to produce printed or on-screen graphics. Indeed, like most graphics software, the very first action when setting up a document in Illustrator is to choose between screen or print as the intended output. It therefore offers little specific support for those practitioners designing engravings. Whereas in digital typography software, the lexicon and workflow of a typesetter’s workshop has been recreated and then enhanced, and in photography editing applications the tools and techniques of the dark room are applied to pixels,
there is no such legacy in the software of digital engraving. Even in those programs that are specifically developed for creating engraving designs, we see more influence from the world of existing graphics software than from the engraver’s bench; with ‘vectorisation wizards’, ‘gradient fills’ and ‘distortions and special effects’ notable features of one engraving program (see EngraveLab).

Perhaps the most telling result of using software developed for generating print or on-screen outputs is the wide availability of tools that convert photographic images into variable depth engravings. In the example of laser raster engraving, the power of the beam can be modulated with reference to the colour values of an image. As it passes back and forth over a surface, the laser beam etches with more intensity in the darker sections of an image, burning a result that looks as though it might have been printed. Whilst such techniques doubtless offer creative opportunities to the practitioner, it appears that there is more interest in recreating the fidelity of photography than exploring the opportunities for digital hardware to extend the expressive potential of engraving.

Despite their drawbacks, however, programs such as Adobe Illustrator, do offer the opportunity for users to develop and run scripts, to extend their usefulness. Scripts, like the Petra Sancta script, are pieces of code developed, either by Adobe or a third-party, to enhance the functionality of Illustrator. They can be installed by the user and then accessed from within the application. Scripts usually offer a novel feature to users, or can be used to automate repetitive command sequences.

Once installed, the Petra Sancta script may be used to recognise areas of artwork that are filled with any of the Petra Sancta colours (a group of specific colour swatches is bundled with the script), and then replace those colours with the associated hatching style (Image 2). The script generates vector lines using a process that we have found to create robust files when exporting into other formats for various cutting hardware. Indeed, one of the motivations for creating the script was to avoid the frustration of using Illustrator’s native ‘pattern’ feature to create vector lines that were unreliable when exported. The Petra Sancta script therefore offers an efficient means of specifying hatching patterns for both laser and rotary cutting tools, which we hope can support the use of the convention, and more nuanced engraving techniques generally. Although developed with the traditional patterns of heraldic engraving in mind, we see it having much broader application, as a more sophisticated alternative to the solid raster fills of laser engraving or the efficiency-focussed pocketing of rotary cutting software.

Summary

In addition to its usefulness in practice, the Petra Sancta script is intended to demonstrate how, as we build increasingly dexterous hardware, software can be developed to support and encourage a sensitivity to the principles or connoisseurship of a craft.

With ever increasing access to digital fabrication techniques, we believe that it is important for digital practitioners to recognise the existing knowledge in the more traditional variants of their fields and to consider how this knowledge might best be translated into digital hardware and software. Our goal was to take one of the principles of best practice in engraving and apply it in design software. This small effort has provided us with a useful tool and a better understanding of the potential for modifying software.

Learning more about traditional engraving, however, has also made clear the relatively unsophisticated processes and results of digital engraving – we have found many other aspects of best practice that remain unsupported in our machinery and software. Furthermore, despite their rapid advances and huge growth in availability, we believe such unsophistication might be true of all digital fabrication processes. There is still much to be improved, in both our software and hardware. And, if you are wondering where to start – we would urge you to buy an old how-to guide.

The Petra Sancta script is open source, and can be used and modified by other practitioners. Please visit www.jethomas.co.uk/petrasancta to download it.

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Philip Luscombe is a Graduate Tutor in 3D Design at Northumbria University. He is a product and furniture designer, with a deep interest in the processes of making and their relationship to design. His current PhD research investigates the improvisatory nature of workshop practice. In the context of increasingly digitised manufacturing processes, Philip explores the contrast between understandings of production that prioritise accuracy to a predetermined form and those that rely on step-by-step adaptation. He also teaches and designs furniture for production.

James Thomas is an Experience Prototyping technician at Northumbria University. Years spent working with artists, designers, makers, educators and researchers have broadened James’s expertise, originally from the field of software development. He is now capable of work throughout the spectrum of digital artifice, from pure code to physical manufacture. His key interests lie in producing beautiful digital artefacts with atypical user interaction, ideally with a social good driving them and producing software to aid the creative and craft practitioner. James usually works collaboratively in the fields of: electronics hardware & software; software design; coding and debugging; digital fabrication (specialising in 3D printing and laser cutting); and much else besides.
Research Question
How do creative episodes arise in the designer-maker’s use of analogue tools? How can creative episodes arise in the designer-makers use of digital generative software tools? What are the differences and similarities between these types of tools?

Method
This paper uses a mixed methodological approach. Literature from the fields of design and creativity research, particularly of Margaret Boden (2003), has provided a framework of mechanistic creative typologies. Reflection and analysis of the author’s own designer-maker practice provides examples of how such mechanisms can be facilitated by generative tools. Further evidence was gathered by interviewing designer-makers about their practices, particularly focussing on the creative episodes that stimulated particular pieces or collections of work and how tools were involved in these.

Tools
Characterising generative design systems as ‘digital tools’ has been discussed in academic literature by McCullough (1998) and Oxman (2006), who have both explored the idea of the analogous nature of the use of generative systems with physical tools and materials. A designer-maker is a particular kind of designer that designs through the activity of making: working closely with tools and materials to design objects that they either produce themselves or with the help of others. Digital tools have been adopted into the designer-makers practice in the last ten to fifteen years with the advent of easier access to digital software and digital fabrication tools, such as laser cutters and 3D printers. How does the designer-maker actually use tools, in particular digital tools? Design theory has a tradition of close examination of sketching in design processes (Oxman, 2002; Schön & Wiggins, 1992) to try and gain insight into the physical and cognitive operations of the designer, but little similar research exists for designer-makers working directly with materials.

A formal descriptive model that may be useful to adopt is a particular theory of design called shape grammar, originally developed by Stiny (2006). In shape grammar two or three dimensional shapes are transformed by rules, performing operations such as addition, subtraction, affine transformations and translations on points, lines, planes and solids, rules are visually represented as shown in Image 1.
Shape grammar was first used as a way to design by computing with shapes a set of shape rules that can be used to define a design and generate new versions (Stiny, 1977), or simply used as explorations of shape and form. They have been the basis of digital generative design tools (Koning & Eizenberg, 1981). Later research on shape grammar recognised its strengths as a theoretical and philosophical way of thinking about designing (Stiny, 2006), where the actions of designers can be described and analysed.

If we take making to be a process of transforming materials step-by-step with tools, we can align this with the idea of transforming shapes by applying successive rules. We can characterise tools as a kind of rule used to transform material. Digital tools and computational rules are one in the same, and perform transformations on digital media. Viewing tools in this manner gives us the key to using ideas from creativity literature to formalise creative activities in designer-maker practices.

Creativity
What is creativity? Margaret Boden, a widely known researcher of creativity and artificial intelligence, describes a creative idea as one that is 'new, surprising and valuable' (Boden, 2003). We assume that such objects enhance the human experience and is something we strive towards as designer-makers.

How can we be creative? According to Boden and other creativity research (Csikszentmihalyi, 1996), creativity may be characterised by the original manipulation of formal rules of a particular conceptual space or domain to create a new artefact. Examples of conceptual spaces often cited in creativity research are things like Haiku poetry, or musical styles, where rules determine the form of an object of the domain. Boden defined creative actions into formal computational categories as she was interested in whether artificial intelligence systems were capable of creativity. The idea of rules being the key to creative activity fits neatly with the discussion of rules, tools and generative design in the previous section.

Designer-makers interviewed for this research were very concerned about their domains and their very specific position within them, how they wanted their work to be perceived by adhering to or even breaking certain rules. Indeed echoing the language of Boden, maker and writer Dormer (1994) also states that craft activity ‘follows rules, conventions and patterns’. In craft disciplines, the main definition of the domain are the tools and materials used. So what kind of manipulations of tools, rules and materials yield creative episodes? And how do these occur in designer-maker practice with analogue tools, but also with digital generative design tools? The following sections address these questions.

Searching the Space: Explorative making with tools
Boden’s first classification of creative behaviour is that of selecting and exploring an established conceptual space. The designer-maker’s discipline is a conceptual space, predominantly defined by tools and materials as well as other rules and conventions. A generative design tool is a defined conceptual space, comprised of computational rules. The process of using a generative software tool to produce forms is a creative activity; it can in fact automate the exploration of the rules it is comprised of. It is much like a maker producing a range of test pieces in a material using the same tools and materials each time, but with chosen variations in the actions. How and when tools or conceptual rules are used in a making process yield different outcomes, some of which may be creative.

The user of a generative design tool can allow it to search the whole conceptual space it has been programmed with, returning an array of forms, potentially every possible form if the tool has a small number of variables. Image 2 is an example of some outputs from a very simple shape grammar generative design tool, in part using the shape grammar rules from Image 1. The rules have been applied to random shapes, a random number of times, producing a selection of different designs.

The number of potential outputs of a generative design tool may run to very large numbers if there are many variables. Image 2 is an example of some outputs from a very simple shape grammar generative design tool, in part using the shape grammar rules from Image 1. The rules have been applied to random shapes, a random number of times, producing a selection of different designs.

The process can be more or less guided by the user. A less controlled approach can be taken, letting the generative tool search the space with random input variables in the
hope it returns something useful as in Image 2. Makers often employ this tactic in their practices, deliberately letting tools find the form in their work. One example is Ian McIntyre, a tableware designer who made pewter bowls by swirling molten pewter round a mould. Each bowl was completely individual due to the complex dynamic physical forces at play.

Using both physical and generative tools, this approach does have downsides. Many useless versions are likely to be produced, whether the rejection of these is down to aesthetics, functionalities or close repetition. This may waste time in these cases, the beauty of pewter is it is easy to melt down and start again; digital entities are even easier to rework. It may be worth experimenting to find something worthwhile.

In engineering the outputs of generative design tools are often then fed into an optimisation algorithm to siphon off the useful solutions within the generated design possibilities. For designer-makers it is likely that they perform this task as it is likely to be a question of aesthetics, something that computers have still not yet mastered. Again, a maker would review their works made with analogue tools, and select ones that they found to be useful.

More likely, is that the generative tool, like an analogue hand tool, can be guided by the designer maker. By changing the variables values a level of interaction is usually available in a generative design tool. The user can see onscreen and in real time the effects of the changes they make. Designer theorist Schön has developed well-known protocols about how designers perform a routine of ‘see-move-see’ making observations (Schön & Wiggins, 1992), followed by a transformation, followed by more observations of the results. The maker can make judgements about the results of their actions and continue with the next move accordingly. The same protocol can occur in generative tool use. The input variables can be adjusted as the user works cyclically between their input and the output.

Like physical making, searching a conceptual space in a generative tool can have a tacit element. Some generative design tools have an underlying computational physics engine, which allow the user to manipulate forms by hand, not just numerical values. One example of this is seen here in the generative programme Jenn3D, a freeware programme that allows complex geometries to be stretch and inflated with the cursor. The author manipulated the forms and used these to make jewellery via 3D printing and casting.

**Transforming Conceptual Spaces: Making with transformed tools & new tools**

According to Boden a higher level creative activity is to go beyond searching a known conceptual space and actually transform it in some way. These transformations can range from small changes (bending or tweaking rules), to dramatic, surprising conceptual shifts that produce whole new domains. The result being that these can then be used to produce novel artefacts. How can such creative shifts occur in tool use by the designer-maker?

One way this is possible is by bringing generative tools into new domains and subverting the intended use of the tool. The author did this by using the freeware program Jenn3D. Intended as an visualisation tool for mathematicians, it allows the user to visualise, manipulate and export complex three dimensional geometries. For those that have some digital knowledge, but no programming experience, this transference of a software tool from another domain is a good way to be creative. Like an analogue tool, you do not have to understand the inner workings of a generative tool to use it successfully. You don’t have to understand the mechanics of a lathe to subvert its use for creative ends.

Transforming a domain is also possible by transforming the digital tool by hacking or rewriting the underlying system or code. This way of transforming the underlying computational rules is similar to how a silversmith would file and shape their hammers to create different shapes or texture on metal.

In digital terms, this has been undertaken by makers such as Drummond Masterton who hacked the machine code for a CNC milling machine to fundamentally change the way it cut metal (Masterton, 2007), resulting in a body of work with distinct and rich characteristics, departing from the homogenised look of material cut by milling machines.

Perhaps the most creative transformation of conceptual space in terms of tools, is to make your own entirely new tool. This would constitute a new domain and is very creative behaviour. Anton Alvarez (www.antonalvarez.com) did this by inventing a thread wrapping machine, a tool that can be used to bind pieces of wood with glue soaked threads. He describes this as a ‘new craft’. The results are creative objects,
very different from any other kind of furniture joining process. The tool becomes a new conceptual space for exploration. Again, it is possible to build a completely bespoke generative design tool. For instance, Nervous-System (http://n-e-r-r-o-s-s.com), a company that pioneered generative, customisable jewellery, has done this many times, using algorithms based on natural morphology.

**Skill**

Hacking and building generative design tools does require the attainment of some coding knowledge. The most dramatic difference between analogue and digital tools is that coding is a different kind of skill from much craft work, but shares some common ground. It involves the learning of conventions and building up of expertise through practice. Most programming environments, like Processing and Grasshopper come with libraries, tutorials and online forums. Starting from a complete blank sheet is not usual or necessary as modules of code and ready-made rules/tools are available in most coding environments. Dormer’s investigation of attaining skill (1994) revealed that attaining craft skill involved the learning of rules, preferably from a master, something that corresponds with learning to program, either on-line or directly from a teacher. A greater level of knowledge or skill within a domain also means a maker is likely to be able to be more creative. Being able to understand and manipulate tools and rules is more likely to lead to creative outputs.

**Creative Episodes: Tools and analogy**

These are the ways that transformations can be made on generative design tools, and are similar to those we can do with traditional analogue tools. But choosing what tool or rule to use, subvert, transform or build is another challenge. There tends to be a moment in a creative process where some kind of leap (Boden, 2003; Koning & Eizenberg, 1981) occurs that brings a new idea to the fore. There are also mechanisms through which these leaps can occur. How these happen for the designer-maker are now discussed.

Much creativity literature purports the use of analogy (Boden, 2003) to trigger new combinations of concepts, which in turn produce new conceptual spaces and creative ideas. A point of correspondence is discovered between two conceptual spaces, or in the case of the designer-maker, two tools.

A neat example of this, which straddles physical and digital tools, is the work of Kathryn Hinton. As part of a research project she has developed her own haptic digital tool; a hammer with internal motion sensors that plugs into a computer via a USB port and works in conjunction with computer modelling software, replacing the usual input of the software use for a new personalised use.

The idea for this came about through analogy: when describing the new tool in an interview with the author she used several ‘like’ comparisons with other tools, ‘like a hammer….like a (Nintendo) Wii…like a Wacom pad’ (Hinton 2011). The link coming through the idea of digitally catching the movement of her making actions. These analogies had led towards the creative idea of a digital, silversmithing hammer, mapping the haptic use of a hammer with that of tools used for haptic inputs for computers. The resulting pieces of silverware are produced with digital fabrication techniques and have a novel and distinct aesthetic that is new to the world of silversmithing.

A more complex version of this is concept blending (Nagai, et al., 2009). Bringing together two concepts through a shared point of reference and then blending aspects of them into a third completely new entity is a source of creativity. In the author’s interviews an example of this was seen in jewellery designer Eleanor Bolton’s work for her MA at the Royal College of Art. Bolton blended the concepts of the jewellery archetype of chain making with tools and techniques from textile crafts, using the shared reference point of the idea of joining loops in a continuous length (see Image 6). She began hand stitching cotton rope together in coils to create wearable, soft tactile tubes.

Generative design tools can be used for blended concepts. If a concept can be defined as a computational rule then it can be combined with others. This occurred in a project undertaken by the author, titled the Butterfly Tool, a digital generative design tool was designed to demonstrate some ideas surrounding generative design to the public. The point of reference used was the wireframe shape of a butterfly wing. The digital medium allowed the Voronoi algorithm, a purely geometric algorithm, to be blended with shapes and intuitive ideas about natural diversity to give a new concept communicating ideas about generative and customisable design.
Emergence

Even simple sets of rules and tools can produce unexpected results and sometimes these emergent possibilities can be serendipitous for the creative process. This happened in Eleanor Bolton’s use of physical tools and processes when she happened upon the possibility of adding and dropping stitches in her tube-making process, giving her a new creative idea for use in her designs. This gave the varying widths in the stitched tubes creating interesting forms, seen in Image 6. This is also something that happened to the author whilst using a self-made generative tool made on CAD program Grasshopper and Rhino, to explore possible wire work jewellery designs. While using the tool, the author spotted an emergent visual phenomenon as the number of wires was increased. Moiré effects appeared and moved around as the forms were viewed from different angles. Realising this was an interesting phenomenon that would be attractive in jewellery, it became the fundamental creative idea for an award winning collection of 3D printed jewellery.

As in making, spotting useful emergent features when using generative tools requires a trained eye. Design theorist Oxman points out that a crucial aspect of making use of serendipitous emergent properties is a requirement of the user to anticipate and, critically, to recognise their presence (Oxman, 2002). Similarly McCullough (1998) points out the importance of the user being able to spot ‘algorithmic beauty’ in the digital on-screen milieu. In craft terms, this is complies with the idea of connoisseurship (Dormer, 1994), the skill of spotting qualities in objects through learning a craft.

Conclusions

This paper has examined how tools feature in the creative process for designer-makers and the many similarities between the use of analogue tools and digital generative tools for creative outcomes. It has been seen that both analogue and digital tools operate as rules for transforming materials throughout a making process, via the lens of shape grammar theory, and that the use, transformation and invention of rules is crucial to creative activity.

Like analogue tools, it has been shown that digital generative tools are open to many creative practices; these include explorations of exponential possibilities, subverting originally intended uses, transforming and hacking intrinsic rules embedded in tools. They are also fertile ground for the occurrence and embodiment of creative episodes, such use of analogies, concept blending and useful emergence. Designer-makers should find ways of working successfully with digital generative design tools to be familiar to them from their work with analogue tools and may find them useful in their work.

The author found that throughout a design and craft education formal, explicit strategies for being creative were never taught, yet levels of creativity and originality were what the students were ultimately judged on. The outcomes of this research, defined strategies for creative activity with tools, may have pedagogical applications, and it is intended that this will be explored in further research; introducing the idea of transformational rules from shape grammar and creativity literature and the forms they take – predominantly as tools in the making process, could be a useful concept for teaching students and designer-makers how to be creative in their practices, whether using analogue or newer digital tools and processes. If a practitioner has a clear idea of what creativity is and how it can be achieved they are more likely to succeed in designing and making new, valuable and useful objects.

References


Lynne MacLachlan is a graduate of the Royal College of Art, is currently undertaking a PhD with the Design Transformations group of the Open University, researching the role of tools in the creative process, and is a visiting lecturer at University for the Creative Arts. Lynne also works as a designer, making innovative, contemporary jewellery and objects using bespoke software and 3D printing alongside more traditional craft techniques. She has exhibited widely in the UK and Europe, notably with the Crafts Council and the V&A museum and participated in live projects with Tiffany & Co and Swarovski.
Design-Archaeology: Bringing a Pictish inspired drinking horn fitting to life

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Introduction
The Glenmorangie Early Medieval Research Project re-created objects from the period 300-900AD in collaboration with artists, designers and makers. A combination of contemporary and traditional craft was used and were informed directly by the archaeological evidence. This collaborative process of re-creation has allowed us to experience these ancient objects as new, giving us insights into how they were made, experienced and used.

This co-authored paper explores one of these collaborative projects; the design and making of a Pictish inspired drinking horn fitting using traditional as well as integrated digital techniques. We will begin by laying out the motivations behind the re-creation. Then, in turn, each of us will reflect on the process and insights made along the way (the designer and the archaeologist).

Recurring themes are; the need for transparency in collaboration, Pictish problem-solving in contemporary process-led learning and authenticity.

The Commission: Mhairi Maxwell
Inspired primarily by the exaggerated comical bird-head on the end of the Bullion man’s drinking horn (Image 2), the Glenmorangie Research Project commissioned designer and maker Jennifer Gray to make a silver zoomorphic fitting for a drinking horn (the horn itself had already been made by Johnny Ross, a horn-carver based up in Sutherland). The making of this fitting was displayed as a work in progress (illustrating its conception from 3D modelling and printing through to the final silver cast object) in the National Museum of Scotland’s Creative Spirit exhibition from October 2013 –February 2014.

In trying to understand craft and how these objects were experienced in the past, there is always a creative tension between the craft techniques available to the Early Medieval people and new innovative technologies available to us today.

The Glenmorangie Research Project was concerned at making authentic re-creations of Early Medieval objects through using the skills and knowledge of today’s contemporary makers. This is different to the traditional experimental archaeology approach which attempts to work within the exact conditions and methods of making thought (by archaeologists) to have been used in the past. There are limitations to this approach which is often constrained by the lack of surviving evidence from workshops. For us, in this

Abstract
The Glenmorangie Early Medieval Research Project re-created objects from the period c.300-900AD in collaboration with artists, designers and makers. Contemporary skills and traditional crafts were used, informed directly from the archaeological evidence. This process of re-creation has brought these objects to life again, giving us insights into how they were made, experienced and used. This paper will present the collaborative processes involved in the latest re-creation of a silver terminal fitting for a large drinking horn with researchers and curators Mhairi Maxwell and Martin Goldberg, and designer and maker Jennifer Gray. Digital design and modelling processes were blended with traditional hand-making techniques to re-create the silver zoomorphic fitting.

Inspired by a 2D image on an Early Medieval carved stone and contemporary Pictish silver metalwork. The final piece was displayed as a ‘work in progress’ (illustrating its conception from 3D modelling and printing through to the final silver cast object) in the National Museum of Scotland’s ‘Creative Spirit: Revealing Early Medieval Scotland’ exhibition, from the 25th of October 2013 to the 23rd of February 2014 (Image 1).

Our design-archaeology approach towards material culture allows for a new way to re-evaluate Early Medieval insular art. Jennifer Gray’s work connects the innovative and traditional methods of re-creation used by the Glenmorangie Research Project; there has always been a tension between authentic craft techniques available to the Early Medieval people and new technologies available to us today. In this paper, we will negotiate questions that arose of authenticity, transparency and creativity that our particular collaborative approach to recreation. The process of designing and making has added to our understanding of these types of fittings; highlighting the decisions made by the maker along the way, their aesthetic qualities and probable functional features of Pictish drinking horn fittings. This piece would not be possible without Jennifer’s experience of both traditional and current digital methods. This project demonstrated that new technological approaches can be blended naturally into a piece of work as a means of enhancing what’s gone before – to bring the past alive.

Keywords: Authenticity, re-creation, design-archaeology, Pictish-problem solving.

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Introduction
The Glenmorangie Early Medieval Research Project re-created objects from the period 300-900AD in collaboration with artists, designers and makers. A combination of contemporary and traditional craft was used and were informed directly by the archaeological evidence. This collaborative process of re-creation has allowed us to experience these ancient objects as new, giving us insights into how they were made, experienced and used.

This co-authored paper explores one of these collaborative projects; the design and making of a Pictish inspired drinking horn fitting using traditional as well as integrated digital techniques. We will begin by laying out the motivations behind the re-creation. Then, in turn, each of us will reflect on the process and insights made along the way (the designer and the archaeologist).

Recurring themes are; the need for transparency in collaboration, Pictish problem-solving in contemporary process-led learning and authenticity.

The Commission: Mhairi Maxwell
Inspired primarily by the exaggerated comical bird-head on the end of the Bullion man’s drinking horn (Image 2), the Glenmorangie Research Project commissioned designer and maker Jennifer Gray to make a silver zoomorphic fitting for a drinking horn (the horn itself had already been made by Johnny Ross, a horn-carver based up in Sutherland). The making of this fitting was displayed as a work in progress (illustrating its conception from 3D modelling and printing through to the final silver cast object) in the National Museum of Scotland’s Creative Spirit exhibition from October 2013 –February 2014.

In trying to understand craft and how these objects were experienced in the past, there is always a creative tension between the craft techniques available to the Early Medieval people and new innovative technologies available to us today.

The Glenmorangie Research Project was concerned at making authentic re-creations of Early Medieval objects through using the skills and knowledge of today’s contemporary makers. This is different to the traditional experimental archaeology approach which attempts to work within the exact conditions and methods of making thought (by archaeologists) to have been used in the past. There are limitations to this approach which is often constrained by the lack of surviving evidence from workshops. For us, in this

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instance, such an approach was not a viable option since there is very little silver-working evidence remaining from the Early Medieval period of northern Britain (pre 1100 AD).

Indeed, there is much material culture involved in metalworking process which would not survive as it is organic or debris which is microscopic in scale.

Evidence

Much of the surviving, contemporary evidence are artistic depictions or written sources and the challenge for us was to translate this into a 3-dimensional object.

We took, as our main inspiration, the Early Medieval carved stone from Invergowrie in Angus, known as the Bullion Man, which is a 2D representation of a mounted warrior at charge (or drunk-in-charge), clasping a large drinking horn with exaggerated beak-headed mount (Image 2). We chose this as it is a popular object in the National Museum of Scotland’s collection, due to its comical and naïve quality. There is a concentric fluidity in the layout and framing of this depiction; man and object are one (perhaps a reference to a cosmology of shape-shifting which is arguably referenced widely in Pictish zoomorphic art). Further, inebriation may have initiated (been central) in Pictish belief systems. Despite not having the Pictish symbols, which often define Pictish art, this depiction is very Pictish in character, and yet drinking horns of this size have only survived from contemporary Anglo-Saxon and Viking burial contexts. We were interested in what we would learn by translating this unusual Pictish depiction of a drinking horn into 3D.

Other inspirations included the silver rim drinking horn fitting from Burghead, Moray (Image 3), Anglo-Saxon Sutton-Hoo and Taplow drinking horns, from Suffolk and Buckinghamshire respectively. Consistent with Anglo-Saxon metalworking, a combination of parts and techniques were used in the Taplow and Sutton Hoo horns; cast features were combined with repoussé decorated gilded-silver sheet in order to make-up a form.

On the other hand the Viking Age Pierowall drinking horn mount from Orkney (Image 4), and objects from the Ninian’s Isle treasure from Shetland (e.g. Image 5) (a hoard which contains what is considered the best examples of Pictish silver work) are forms that are predominantly cast whole in silver (and then sometimes embellished). This is consistent with the few moulds which have survived from Pictish sites.

For our commission, and in order to keep with the Pictish tradition and context of the Bullion Man, we decided that it should be a solid silver fitting where pattern and form is cast into the design.

Design-Archaeology

By bringing such an object to life using modern-day techniques and craft know-how, it was our belief that we could gain some insight into the making and social context of these sophisticated, but now non-existent, objects.

This is what we call Design-Archaeology; a presently situated process-led approach informed by the archaeological archetype. The archaeological evidence is interrogated and directly informs the contemporary design. In turn, we learn about the original object through modern-day know-how, skill and technique.

We use the word re-creation deliberately. Re-creation means to make anew. Indeed, craft process is a living thing and the responsibility of archaeologists is to bring the past alive. By acknowledging this, a reflexive insight into the experience of making in the past can be gained through the hands of a skilled contemporary crafts-person. For the archaeologists, the opportunity to work with designer and maker Jennifer Gray, who uses a combination of digital and traditional carving/silver casting methods, could effectively explore the tension between traditional and new techniques. We felt that the very ethos of re-creation was encapsulated in this process, which brought the past alive using innovative tools available to the present generation, but in constant reverence to the original object(s) (i.e. the Pictish evidence). Like makers from all eras of history we, like them, were building on tradition and at the same time taking advantage of the techniques available in the present day to make work.

Designing and Making: Jennifer Gray

Because of my busy schedule, I wasn’t able to commit to the project in a timespan that would allow for the use of entirely traditional making techniques to re-create the end-piece. I offered a solution; to lower the risk of anything going wrong and to ensure satisfaction with the final object, I recommended integrating digital designing and making techniques into the traditional wax carving and casting methods. Using a blend of conventional and modern techniques would
help to streamline the process yet produce an object which would still appear convincingly Pictish.

As a way of using the little time we had to produce the work effectively, I suggested that we should open the show with a digital maquette of the horn-fitting and invite the public to monitor its progression up to the final unveiling six weeks later.

A 3D printed prototype of the end-piece was on display throughout the first half of the exhibition and the public were able to track the development through the National Museum of Scotland website which published up-to-date images of the making process. The finished piece was unveiled at a one-off special museum event where the public were invited to handle/view sketches and models, which were part of the development process.

This work in progress approach was considered a risky undertaking by the National Museum of Scotland. Any delay or even a potential failure to deliver the finished piece could have cast the project in a negative light, especially where the public was concerned, as the unveiling of the final piece was advertised on the National Museum of Scotland website (archived here: http://www.nms.ac.uk/explore/collections-stories/scottish-history-and-archaeology/early-medieval-scotland/bringing-the-past-to-life/drinking-horns/), in the general media and alongside the actual model prototype during the exhibition. There was a worry that the project might have been perceived as a failure or an unwise monetary investment if the final piece did not appear as advertised. A process led investigation could have resulted in the final piece differing from that which had originally been proposed. However, for the purposes of our investigation, any mistakes and failures were all a valuable part of a problem solving process. In the end all agreed this approach actually turned out to be very successful since it created a new line of interest for the public and exhibition organisers who all enthusiastically engaged with this transparent process.

The Design Stage
I was required to produce an object that when finished would sit convincingly within an Early Medieval context. Although I was granted the freedom to design (whilst adhering to the sources provided to me by Mhairi and Martin) I still wasn’t completely comfortable simply to follow my own design process since it was important that the final object would not be recognised as a piece of my work.

Therefore, the design stage became a full collaboration. It was a give and take process where designer and archaeologist worked together using the aforementioned sources to hone and justify an appropriate design for the end piece.

Modelling Stage
The horn could not be allowed to leave the museum premises. Therefore used a 3D modelling program called Rhino to make a digital version of the horn to give me something to work with in my studio (Image 10).

ABS plastic is not the most appropriate material to use to represent fine nuances of detail, surface pattern and the subtle angles of edges, but it was useful to
represent the overall appearance and it was obvious that the fitting would take its final proportions from the horn. It acted as a quick and cheap snap-shot of the stage I was at in the making process.

It strangely appeared like an out of place prosthetic when it sat on the horn at the exhibition opening. We were laying our process bare and not trying to disguise it as something in-keeping with the other objects on display. It stuck out like a sore thumb. However it was essentially a tool for us, a means to check if we were going in the right direction.

At this stage I was able to identify the features that needed altering. I was able to load up the model as it stood and continue to manipulate it from the point at which I had stopped to print the ABS maquette.

I had originally intended to digitally carve the entire piece, which would then have been 3D printed in high resolution Objet resin, moulded and then cast in silver. However, no matter how many different manual settings I used in the digital carving program the depth of my relief carving was always totally consistent, which I felt made it appear too artificial. I had a rethink and decided to add to my making process by incorporating hand carving.

Looking closely at Pictish sources from the museum such as the chape (a fitting for the bottom of the sword sheath) from the St Ninian’s Hoard, I could clearly observe the original maker’s inconsistency of depth in his relief carving and the asymmetry of the surface pattern (Image 5). My ultimate intention was to create a piece that would sit convincingly amongst other objects re-created from the Early Medieval period included in the same exhibition.

I felt that by using steel hand tools I could learn more about the techniques which had been used so long ago by a Pictish person. I was then able to understand the reason for the pattern’s asymmetry when trying to fit in a variation of complex Pictish shapes and patterns into such a limited space.

Virtual carving is done through a software program where a virtual block of wax appears on my computer screen and I carve it as you would by hand. By using this method I substituted my steel wax carving tools with a USB drawing tablet. In order to retain a hand-made quality I carve using only manual settings. In this particular case, I digitally carved the zoomorphic fitting without any surface relief pattern. I 3D printed it in high-resolution objet resin which was then moulded in silicone (Image 11). I poured carving wax into the mould, then after I had finished using the virtual tools on the computer, I continued carving manually with steel tools (Image 12).

Integrated Technologies
For me the essential reasons for using digital technologies were:

- Simply, the digital technologies enhance the design and making experience.
- The piece was quicker to make and the technologies enabled me to have more control, limiting the chance of mishaps. I had the advantage of being able to work offsite with my digital model of the horn and this helped me with the tricky task of making a fitting for such an organic, inconsistent twisting form.
- It is very useful for trouble shooting. I didn’t need to interrupt my flow of process to take the time to whittle out the maquette in wood for the opening of the exhibition. The 3D printed maquette represented a snap-shot of the stage I was at in my making process which I could continue to manipulate thereafter, and did not distract me from the overall process. The work in progress display helped to engage new public audiences with the making process and the use of digital tools.
- It occurred to me just how special and precious the objects we were recreating must have been in their day. It would have taken craftspeople vast amounts of time and effort to make the objects using the tools and limited material resources they had. Unfortunately, today we don’t have the luxury of time, but it was very satisfying for me to demonstrate that through the use of digital

Image 10.
The ABS plastic maquette on horn.

Image 11.
The moulding process of the final Objet 3D printed model.

Image 12.
The final wax end-piece after the application of hand carved surface relief pattern.
technologies and today’s tools and machinery you can re-create, as best as possible, a piece of ancient treasure in a couple of months.

- In creating this piece, I could limit the limitations of both manual and digital methods and use a combination (the best of both), to make an object, which was on time and exactly fitted the brief.
- It would not have been possible to have fully re-made this piece as it would have been made in the past. If I was to have carved this piece entirely by hand I still would have used my modern steel hand tools, modern casting processes, modern machinery for finishing and polishing. I also have used a modern silver alloy which would probably not have matched the material which was used in the past. I essentially used the same gestures, while alternating between a virtual and real-life working environment, to make the end-piece as the crafts-person did all those years ago.

So then why not introduce new technologies into the blend to make an object that feels and appears convincing, yet is made much more efficiently (Images 13, 14 and 15)?

**Discoveries: Mhairi Maxwell**

So, what did the archaeologists learn through this collaborative process? I gained great insights into the stages involved in making a drinking horn fitting: the materiality of silversmithing (and immateriality of 3D technology) and how such a fitting would enhance the function and social role of a drinking horn in the Early Medieval period.

**Making**

Manipulating the virtual wax and carving into the 3D form digitally was very valuable, especially since most of the evidence was 2D (although objects, even the Ninian’s Isle chapes are very flat in form, almost as if the pattern were applied in 2D). This digital toolbox allowed us to experiment efficiently with form 3-dimensionally, which the zoomorphic drinking horn fitting depicted on the Bullion Man stone required. It was very cost-effective, and allowed us to fail several times, but with no additional expense.

The most interesting moment was when Jennifer decided to change to carving the design into the wax, rather than continue virtually as originally planned. This was to capture the **inconsistency** and **hand-made** quality that Jennifer noted in the execution of the decoration on the St Ninian’s Isle chapes. The 3D result would have been too rigid. The flow and movement of Pictish pattern had to be captured in our final design.

The hand-tools used by Jennifer today have hardly changed since the Early Medieval period (Image 16). Although planned to a degree, interestingly Jennifer talks about learning a formula through the carving/incision process; the geometry occupied the space and emerged iteratively through the hands and tools controlled by Jennifer, directly informing the nature and flow of the marks made. Embracing this relationship between 3D form, iterative design, and the tools used, ultimately made the result a more aesthetically pleasing and authentic design.

**Materiality**

Also drawn to my attention was the material culture involved in silver-working, which wouldn’t survive archaeologically (i.e. wax, our modern equivalent being the 3D printed ABS plastic prototype). This has made me re-examine the roughly hewn wooden bird-headed object from Balinderry crannog, published as a ‘fitting’ for possible drinking horn.

I now view this as an unfinished macquette, into which the decoration would be incised and then placed in the mould to be cast in silver. Indeed, primarily, this would have been an organically based craft (in our collaboration replaced by the virtual and the digital), and the final silver objects are in fact solidified ghosts of ornate organic artefacts which rarely survive; metamorphosised skeuomorphs. The translation of warm organic fittings into cold silver drastically changes the haptic (weight and texture) and visual (bright and polished) experience of a drinking horn. I am, however, not privileging metal over organics here, as when we made the horn itself with
Johnny Ross (of Sutherland Horncraft) out of an African Ankole cattle horn, he was able to polish it to such a degree to evoke glass and metal. The large horn used in the Early Medieval period was highly likely from Auroch (wild) cattle, which would had to have been imported from the continent or further afield (as this breed of cattle was extinct on the British Isles by this time).

Use
Therefore, complete drinking horns are a testament of access to a skilled network of craftspeople (who were probably familiar with many materials) and, in investment of materials, were a statement of status (our final fitting weighs a whopping 600 grams of silver). The silver fitting acts as a counterweight and stops the liquid from pouring out all at once and soaking the drinker (our horn held almost exactly one gallon of liquid)! These drinking horns were likely not designed for an individual to drink from, rather they were communal vessels. Belief systems were not exclusive in Pictish worlds, but were engaged with by the community.

Conclusion
To conclude, we want to quote from Glenn Adamson:

*It is in forming a new relation to the past that craft proves most indispensable.* (Adamson, 2013, p.xxii)

Pictish Problem-solving and process-led learning
There must be transparency in collaboration between the past and present, and also between the modern-day crafts-person and the archaeological evidence. Archaeologists are the outsiders looking in and we should respect this. Makers have a more subjective relationship with materials and craft know-how and this should be exploited in our interrogation.

- The archaeologists/ curators played an active role in the designing and making process, which in turn increased their understanding of materials and the design process.
- There was no masking any stage of the process, rather it was very public until the set deadline.
- The integrated technology allowed us to be dynamic and flexible with our approach to making and designing.
- The public were surprised to find that the piece replacing the ABS maquette had a very hand crafted appearance despite being partly made through digital processes.

Authentic Re-creation
The result sat convincingly amongst other Early Medieval objects. In the end the technologies blended naturally into the object. This was a result of the reflexive dialogue between the evidence and its interpretation through modern making; archaeology and contemporary craft are complementary and presently situated. Further, similar considerations and decisions are involved in virtual recreation as in physical recreation, and throughout an appreciation of the sensory qualities and materialities of objects is still gained, from a necessary reflexive point of experience. One of the most exciting things about digital technology is that it offers new possibilities for interrogating objects by bringing them to life, in turn raising more questions. By interrogating fragmentary archaeological evidence with modern day design expertise, aka Design-Archeology, we have together created an authentic re-creation.

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References:
Mhairi Maxwell was Glenmorangie Research Officer from March 2013 until March 2014 at the National Museum of Scotland (a prestigious partnership was established between Glenmorangie and the NMS since 2008 to conduct innovative research on Early Medieval Scotland), and now is based in the Digital Design Studio at the Glasgow School of Art as an RA on the ACCORD project (community co-production of 3D records of heritage). Mhairi has a PhD entitled, ‘Out of the Ordinary: the Materiality of the South-east Scottish Iron Age’, from the University of Bradford, awarded 2012, and is a Fellow of the Society of Antiquaries of Scotland. Her research interests are in Iron Age material culture (worked bone/antler, worked stone, pottery and metalwork), Celtic Art, object biographies and materiality theory, interdisciplinary analytical and scientific approaches in the study of artefact technology and use (raman spectroscopy, residue and isotopic analysis and 3D modelling), digital applications in archaeology, art and craft practice. She enjoys being an archaeologist in an art school. 

Jennifer Gray is an award winning designer/maker and lecturer in the Jewellery and Silversmithing Department at Edinburgh College of Art. She is a graduate of The Glasgow School of Art and the Royal College of Art, London. She produces objects and jewellery in a range of materials using techniques, which move in and out of the hand-made, and the digital. Each series is unified, in particular through use of traditional hand carving methods; enhanced by taking advantage of emerging digital technologies. 

Martin Goldberg is the Senior Curator of Viking and Early Historic Collections at the National Museum of Scotland, in the Scottish History and Archaeology department. His research interests are in material culture in Northern Britain from Later Prehistory to the Early Historic period; Silver - use and manufacture from Roman to Viking period; material culture approaches to the holistic study of ancient religion and ritual practice.
Introduction
The act of making has developed beyond the physical realm of craft to include the creation of digital forms and 3D printed objects. This change has resulted in an ongoing democratisation of 3D software and printing equipment to the point that any craft maker, armed with a mobile phone and a free app, can capture, model, manipulate and print a static object. Where once craft makers would visit a museum or gallery seeking inspiration, viewing and sketching pieces in any given collection, there now exists the technology to digitally record artefacts in three-dimensions. Consequently, makers are able to appropriate existing objects in order to apply their own tools and techniques to the piece. This practise of (re)crafting museum pieces raises a number of issues, regarding: the role of the traditional maker in digital craft; the relative importance of the outcome; and the comparative intellectual property rights.

In order to investigate these issues, I positioned myself as a dual-practitioner experimenting with digital technology. At the time, my work traversed both basket making and public engagement in higher education. These two very different roles did overlap, particularly when it came to my approach to learning. Consequently, I settled on a process focused on experiential learning and reflection, using Kolb’s Experiential Learning Theory (ELT) (1984), and Schön’s theory of the reflective practitioner (1983) to frame and review my craft practice. This approach involved: creating context; developing a framework; learning through concrete experience; engaging in reflective observation; applying abstract conceptualisation to make sense of the project; and considering active experimentation with regard to my future practice.

Having a clear model was important to me because I had a limited amount of time and few resources. I also wanted to prevent myself from over-engaging with the software, in order to remind myself that this was an initial experiment, not a masterwork.

In May 2014, I set myself a three-week timescale to investigate the practice and pitfalls of interpreting a Japanese bamboo basket from the Victoria and Albert Museum collection, using Autodesk 123D®. It was some years since I had engaged with 3D modelling software, so I hoped my earlier exposure to Autodesk AutoCAD® would enable me to master this new programme with some ease. At the time of the project I was also working as the Public Engagement Co-ordinator, School of Law, Queen Mary University of London.
London (QMUL), which gave me access to resources and contacts not necessarily open to other basket makers. In this higher education context, I also regularly applied theories of experiential learning and reflection to my work with students, academics and business development partners.

As a public engagement professional and practising basket maker, I had high aspirations based on existing experience and my understanding of materials, form and pattern making. Needless to say, the resulting object was not an aesthetic success. However, the journey provided me with a valuable insight into the limitations of my skill-set, the parameters of the software, and the possibilities inherent in 3D printing.

**Context: Basketry and 3D technology**

I used the *Oxford English Dictionary* to define digital as ‘involving or relating to the use of computer technology’ (2014a) and craft as ‘an activity involving skill in making things by hand’ (2014b). So, digital craft could be viewed as a marriage of tools – the hand and the computer. In this context the role of the craft maker expands to include making in the digital realm, resulting in the exploration of new technologies, skills and materials.

However, these opportunities are yet to be investigated by basket makers in any large numbers. This raises questions regarding the skill-set and outlook of basket makers, for as McCulloch concludes, in *Abstracting Craft: The practiced digital hand*, the possibilities for craft lie not in the digital, but in the attitude of the crafts person (1997, p. 272). Tim Ingold, in, *On Weaving a Basket*, goes so far as to say that all makers should look to weaving as a model. This could not only reveal a new view of basketry, but of all skilled, form-generating practices (2011, p. 339). So, long before May 2014, I began thinking about how I, a basket maker, could experiment with digital craft. I was influenced by two other projects: a collaboration involving the Museum of New Zealand Te Papa Tongarewa, Victoria University of Wellington’s 3D Production Initiative and the Weta Workshop; and the work of Amit Zoran, Post-Doctoral Associate, Fluid-Interfaces Group, Massachusetts Institute of Technology (MIT) Media Lab, who has developed hybrid basketry/3D printed prototypes.

In late 2013, I visited Wellington, New Zealand, where I spent a week researching Māori basketry at Te Papa. In one of my conversations with Martin Lewis (Liaison Librarian), I mentioned my interest in learning more about digital craft. He said, ‘why don’t you look at what’s going on here’. Te Papa, Victoria University and Weta were in the process of documenting museum pieces using stereoscopic cameras, namely the ‘Genus Hurricane Rig’. As you would expect, this was not a simple exercise. Stereoscopic 3D or Stereo 3D essentially relies on multiple cameras mocking the interocular separation of the human eye to CGI model objects and environments (Victoria University of Wellington, 2013). This particular collaborative project realised digital objects of exceptional quality, particularly with regard to surface representation. As a basket maker witnessing this technology really excited me, because I could see the potential to manipulate these models to incorporate basket weaving. However, the Rig is a specialist piece of film production equipment, of which I have no real experience. I sought to find examples of work based on technology I was more familiar with – AutoCAD®.

Amit Zoran, MIT Media Lab, has explored the divergent realms of digital technology and hand-hewn craft, with the intention of positioning the digital as the producer of control and efficacy, while the hand operates as the maker of cultural and creative expression (Zoran, 2013a). He has completed a number of projects traversing technology and craft, but it was his paper ‘Hybrid Basketry’ (Zoran, 2013b), and associated prototypes that interested me, not least because Zoran is amongst only a handful of people working specifically with 3D digital technology and traditional basketry.¹

In 2011, Zoran visited Maun, Botswana where he learnt basket weaving from a traditional maker, Thitaku Kusonya (Image 1). Zoran found that Kusonya’s work was influenced by her dreams of pattern, alongside local traditions and materials (2013b, p. 325). Having investigated her creative and cultural expression, he set about analysing and transforming weaving algorithms that were based on the work of Zubin Khabazi in ‘Generative Algorithms – Concepts and Experiments’ (2010).

¹. Ueno Masao, a Japanese basket maker and architect, has worked with 3D modelling software, and the architect Shigeru Ban has referenced traditional basket making in his buildings, but there are few others who recognise both the traditional craft and the 3D technology.
Khabazi has created a useful how-to-guide to textile weaving in Computer Aided Design (CAD) spaces. As a result, Zoran created a number of hybrid prototypes, made of printed nylon, reeds, jute and canvas rope. The printed nylon elements were produced via a selective 3D laser-sintering process to form the frame of the basket. Separate layers of natural material were then woven in to strengthen the frame (Image 2). I value his work for three reasons: 1. they are structurally sound; 2. they aesthetically pleasing; and 3. they draw upon the work of a traditional basket maker.

Framework: Experience is everything

In an effort to draw together my own practice-based and professional worlds, I turned to my teaching and learning experience to create a framework for the project. Kolb’s Experiential Learning Theory (ELT) (1984), and Schön’s theory of the reflective practitioner (1983) emphasise the crucial role experience and reflection play in the learning process. This has particular resonance in craft practice, where much learning is tacit and perfected over time.

Vince & Reynolds reinforce this view of cyclical learning in their paper ‘Organising Reflection’ (2004). They describe Kolb’s theory as a process in which ideas are not fixed, but are instead formed and reformed through experience (ibid, p. 2). This belief is evident in his most widely used theory, the Experiential Learning Cycle (Image 3). This is a holistic model that begins with concrete experience, moves through reflective observation to abstract conceptualisation, and active experimentation, then around again. In following this cycle, the craft maker acts as both student and teacher, engaged in a round of learning and instruction, resulting in the continual pursuit of skills, insight, fulfillment and knowledge.

Certainly, this is a brief description of Kolb’s theory and there are many variations and adaptations available today. For the purposes of this project, I chose to follow the cycle and align this with Schön’s work in developing the idea of the reflective practitioner (1983). Again, Vince and Reynolds review Schön’s theory, highlighting the tacit element involved in learning. Schön formulated his view on design in terms of reflective activity, particularly reflective practice, reflection-in-action and knowing-in-action. When a craft maker reflects in and/or on their practice, the objects of that reflection are as varied as the kinds of experience that came before and after making (2004, pp. 2–3).

In essence, the craft maker’s unique view is central to the reflective process and has a bearing on the relative importance of the outcome. I chose Kolb’s and Schön’s theories to reinforce and communicate my own belief: that understanding is cyclical, and that through varied states of reflection experience can be acquired, applied and refined to elevate the acts of learning and making. This practice is a key aspect of lifelong learning, which is akin to mastering a craft.

Concrete Experience: A play at (re)crafting basketry

With this framework firmly in my mind, plus Zoran’s 3D project, and the surface resolution quality of the Te Papa scans not far behind, I sought my own concrete experience; I wanted to be actively involved from the outset. I was aware that the two projects I admired were achieved with the best technology available. I resolved to do what I could, within certain parameters.

The project had to be completed in three weeks. Taking my job commitments into account, the software had to be free to download and use on a device that I already owned, and it had to be supported by a user community who could help if the need arose.

With this in mind, I investigated several options that included the Trimensional 3D Scanner for iPhone (n.d.) and various self-build options (Cornish, 2013). Eventually, I chose Autodesk 123D® (2014a) because: it had achieved a stable release on 21 April 2014; included a range of specialist apps that facilitate 3D sculpting and printing; it had a range of online tutorials; the user forum was well populated; there were already examples of scanned baskets in the object library (2014b); and, ashamedly, I also liked the instructional video, (it looked so easy).

I downloaded the app, Autodesk 123D Catch®, and viewed the online tutorials. The first tutorial explained that the capture process involved taking at least 20 photos around the static object, followed by 20 from above (you could take up to 70 photos in total). You could then load these into the app and it would build a model with a photorealistic surface. At this point it discussed the option of importing the model into the Autodesk 123D Design™ and Autodesk MeshMixer® apps to repair the mesh, manipulate it, and prepare the piece for printing.

I then looked through the object library, which included a number of baskets of differing quality. However, I wanted to apply the software to a museum piece, partly because I wanted to engage with museums, but also because Japanese bamboo basketry is the focus of my upcoming PhD.

Before beginning, I emailed Mr Jonathan Griffiths, BA (Oxon) MA, Solicitor, Reader in Intellectual Property Law, School of Law, QMUL, regarding the intellectual
property rights relative to appropriating a piece of Japanese bamboo basketry. He advised that any museum basket may be protected, potentially by copyright or design law. This protection could extend to uses in a different medium, including scanning software, and to its use in a variant form, where adapted in 3D modelling software. This could be an issue if the basket was made by a living maker.

Even where the basket designer was dead, protection could persist for a long time (the duration of copyright, in particular, could be up to 70 years post-death) (J. Griffith, 2014). Considering Jonathan’s advice, I looked over the Autodesk 123D® copyright information. There is no obvious notice regarding the legality of scanning the work of another, however there is a policy regarding ‘Notice and Procedure for Making Claims of Copyright Infringement’, Legal Notices & Trademarks (Autodesk, 2014c). Anyone who feels their copyright has been infringed can make a complaint. Also, in section ‘2.1 Your Content is Yours’, A360 Terms of Service (updated. 3/2013) (Autodesk 2014d), the onus is placed on the user (the person who scans the object) to obtain copyright pursuant to their particular jurisdiction, which of course meant I was solely responsible for meeting the intellectual property requirements of the project.

I then sent introductory emails to a number of V&A curators and also made contact with a QMUL colleague doing a project at the Geffrye. I got lucky, Xiochin Lee and Rosalie Kim, assistant curators at the V&A offered to let me select a Japanese bamboo basket from their storage collection. I chose a multi-layered, complex weave, nineteenth Century bamboo basket by an unknown maker (Image 4). I confirmed that the copyright for this piece belonged to the V&A.

It was a fragile little basket. It was made available to me on a small trolley in a narrow storeroom corridor, so I had some difficulty getting the full 360° photos. As you would expect, it was on white tissue paper, which meant that 123D Catch® had difficulty registering anchor points related to each face of the basket. As I wanted to abstract the final piece, I hoped that the software would still be able to build a working model. I uploaded my 70 photos into 123D Catch® and got a number of variations (Image 5).

The first one, Portion, was basic due to the poor capture process. Basket, Basket_2, Basket_2a, Basket_4 and Basket_5 were all fragments, which I quite liked. However, the app did process a quality surface image, which is somewhat misleading as the capture is not necessarily reflective of the printed form. Unfortunately, none of the captures registered the spaces between the weave, which was disappointing as this was the best quality of this basket.

I chose Basket_2 as it had a distinct handle, the most interesting surface area, and was small and light weight, which was important when calculating the cost of printing. I converted it to a mesh in 123D Design® (Image 6). This revealed some of the weave and indentations. It looked like a bone, which I really liked, particularly in the context of using a museum piece. I then imported it into MeshMixer®, in which I identified and repaired holes, and altered the surface finish (Image 7).

Finally, I exported the file to STL (STereoLithography) format for printing and was able to preview the piece. Through the Autodesk 3D Hubs® service I found a local designer who could print it on a MakerBot Replicator®
printer for me: Felix, from E8 Makes in Hackney Studios. Image 8 shows the piece in production; the undercarriage is made up of scaffolding, which I removed post print. It was difficult to reconcile the amount of plastic used, particularly as this was not a functional piece but a simple representation of a valued artefact. Image 9 shows the outcome – my little lump of coal. I did attempt to manipulate the piece; I wanted to weave into it with bamboo, but I found that the plastic melted and discoloured when using a jewellery drill and file. I could have polished it, however I would have lost a lot of the surface quality and I liked the lines, they were almost sedimentary, topographical. My little lump is not particularly elegant, nor is it refined, especially when you place it next to the original, but it is very much a result of the process and my experience.

Reflective Observation: Stepping back from the action

It is challenging to engage in reflective observation, without indulging those feelings that dominated the process. I did not enjoy executing this project. In the moment, my sense of frustration was great. Upon reflection this feeling was elevated by other factors, rather than by the specific process. Any leap of faith requires a can-do attitude: the belief that applying tenacity and ingenuity will bring reward. I approached this experience with a sense of optimism, and in many ways this tactic opened doors for me; several of the academics, technologists and museum professionals I contacted were genuinely interested in the project and in my long-term ambitions. I did struggle to find digital experts with whom to engage and as a result I felt somewhat alone in my exploration. At first, working with Autodesk 123D® was exciting, but I was disappointed when the anticipated results did not materialise. The software contained bugs, which meant it crashed regularly. My skills were not as advanced as I had hoped. As a maker I felt very detached from the material, a fact that markedly reduced my enjoyment of the process. The timescale did prevent many of these negative feelings from becoming all consuming. As an exercise, this was a worthwhile experience. In the cycle of learning it was very much a first step.

Abstract Conceptualisation: Making sense of the action

Applying abstract conceptualisation to the experience revealed one clear point of learning: whilst I can appreciate 3D scanning apps and printers as tools, it is now obvious to me that they must operate within a range of options, or the outcome risks being just another piece of plastic. As such, I still find myself questioning the worth of producing just such a piece, particularly when the original artefact was so attractive. At times, it seems as if the marketing around 3D scanning and printing is aimed at promoting rapid reproductions or personal effigies – hobbyist endeavours. It is also widely acknowledged that the software needs of creative practitioners vary from those of engineers, scientists and mathematicians, but the bulk of CAD programmes are developed for the technical professions (Reas & McWilliams, 2010, p.21). This situation provides craft makers with an opportunity to prove the functionality and possibilities of the software and the tools, but it does take time. If I am honest, I expected the tools to work for me more – I am the master of my iPhone, iPad and laptop. So-much-so that I forgot to craft my relationship with 3D
scanning and printing. Certainly, my final piece was not what I had hoped, but the process forced me to persevere and be resourceful. I learnt a great deal. This reinforced my belief in the integral importance of relationships to experiential learning and craft making.

**Active Experimentation: Putting it into practice**

Contending with feelings of frustration and detachment is not such a bad thing, particularly when approaching active experimentation. As a result of my experience, I will put into practice a number of changes aimed at getting the most out of my collaborative relationships, Autodesk 123D Design* and 3D printing equipment.

At present, I think both tools are best suited to preparing components – pieces or frames – to be integrated with traditional basket making. It may be difficult to isolate and scan these pieces in the museum context, but therein lies the challenge. Reflecting on this experience also highlighted that working with digital technology requires layering and play to achieve a unique outcome. This also extends to my relationship with museums; in future, I will make a series of visits to the V&A, rather than one, and explore and enjoy the object first. I will also make specific requests regarding the preparation and display of the basket before I arrive, so I can adequately capture the static object. As Sennett discusses in *The Craftsman*, craft makers should know how to play, rather than focussing on the need to produce the ultimate work (2009, pp. 272-273). After all, play is the missing link between concrete experience and reflective observation.

**Conclusion**

This experience was challenging and at times felt thwarted, but the strict time scale and project framework set reasonable perimeters, which drove me forward. My professional role in higher education enabled me to frame my experience and to access and interest academics and technicians across different disciplines. Although the outcome was far from successful in an aesthetic sense, it resulted in a wealth of new knowledge. In the (re)crafting basketry, my creative aspirations were based on uncertain premises; the software, which inevitably affected the outcome. I overestimated my digital skills, the printing materials and my ability to control the museum environment. However, now, I am more aware of the intellectual property issues that come into play as I move freely through public collections, virtual libraries and the internet. As I embark on my PhD, it is time to develop a new a concrete experience in (re)craftering basketry.

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**References**


Joanne McCallum is a basketmaker working in both the physical and digital realms. She recently took up an AHRC 3D3 PhD Studentship in Digital Craft in the Autonomatic Research Group at Falmouth University, Cornwall. In 2013, she completed a City and Guilds Level 3 Certificate in Creative Techniques in Textiles (Basketry), the last vocational course of its kind in the UK. In 1999, Joanne graduated from the University of Queensland, School of Architecture with a Bachelor of Architecture (Hons 1), followed by a post graduate award in Architectural History and Theory (High Distinction) in 2001. Her PhD explores the relationship between biomimicry, Japanese bamboo basketry and material computation via the production of a range of hybrid craft prototypes that may be of interest to artists, architects and trans-disciplinary thinkers.
Introduction
I understand craft as the skilled process of making, an active and embodied engagement with materials. Ingold (2013) stresses the importance of a person’s involvement in the organic making process of an object to create a more meaningful connection. When pointing out the importance of such active involvement he goes further to state that, ‘I want to think of making […] as a process of growth’ (ibid, p.21). I am drawing on this perspective to creatively explore the complexity and difficulty in understanding embodied interactions between craft practitioners and their materials with novel use of technology and data materialisation techniques.

When documenting the making of a craft artifact, video recordings or image representations are often the preferred medium to communicate some of the more embodied processes of craft practice that may be difficult to articulate. With fast developing innovations in movement capture and digital fabrication technologies, it is becoming more viable to record additional facets of the making process, such as gestures and movements, that can potentially add a layer of depth to the documentation.

An expanding area of research in Human Computer Interaction (HCI) is not only looking at the technical requirements of movement capture and digital fabrication, but is also increasingly exploring the DIY maker community. For example, Tanenbaum et al. (2013) are drawing from the increasing democratisation in the maker movement to develop design implications for future HCI research, including areas such as personalisation and reappropriation.

Additionally, Ratto (2011) introduced Critical Making, which utilises the shared practice of making to engage people with critical reflection on social issues. This shows that academic research is increasingly drawing from maker culture as well as craft practice. The use of digital technology to augment and annotate craft practices and its artefacts is progressively the subject of HCI research, such as Rosner (2010) exploring meaning making and memory of craft practices.

Others, such as Willis et al. (2011), have applied the embodied immediacy of the craft process to digital making by creating embodied, interactive fabrication tools whilst other research is focusing on using digital technologies to explore and better understand the tacit dimension of craft practice, for example Wood et al. (2009). Not only has academic research focused on this combination of craft practice and digital...
The Study

I set up a practice-led design exploration with a group of crochet practitioners ranging in skill level from beginner and intermediate through to semi-professional and professional. In the initial discussion with the group about their craft, I found main points of conversations and importance to their practice were the materiality of the tools, the ‘flow’ and tension of the wool. Additionally, they described crochet and their reasons for enjoying it due to its addictive, productive, meditative, colourful, creative, sculptural nature and it giving a sense of achievement even as a beginner.

The next steps were to start recording and collecting traces of the crochet practitioners’ movements and gestures by fixing accelerometers onto the craft tools, i.e., the crochet hook (see Image 1). In this way, I recorded facets of the making process of a simple crochet pattern, a granny square, to establish a comparable baseline for all participants. The collected data was then translated into different forms to engage the participants. Together with colleagues an interactive sonification system was developed which enabled the crochet practitioner to get direct sound feedback from their movements. The details and findings of this sonification work are not part of this paper and will be published separately.

With the 3D threads of the data showing the variations in stitches alongside the 3D threads of the making process, which Ingold (2013) refers to as flow of consciousness and flow of materials is essential to the making process.

At the intersection of these two threads of the same process, one could see the tool, in this case the crochet hook, as a conduit or negotiator between the two flows. Each flow being influenced not just by one another but also by the tool itself, which plays an important role in most craft practices. With this in mind, I focused in this case study on exploring the movements of the tool as mediator between material and practitioner.

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was attempting to encourage the practitioners to reflect on material qualities, embodied knowledge and shared understanding of their practice. Through these digitally fabricated materialisations, I was aiming to highlight the complexity and difficulty in understanding embodied interactions between craft practitioner and their material, thus drawing a closer connection between the object and its making process as well as the embodied actions of the practitioner.

The workshop was conducted in two parts starting with the unveiling of the materialisations (see Image 3), which were initially hidden under a cloth upon participants’ arrival in order to capture their response as a group rather than individually. Except for the participant’s knowledge of the artefacts being generated from data captured during the first workshop, the shapes were initially left anonymous without explanation to obtain participants’ unbiased responses and interpretations of the artefacts.

After this discussion I then disclosed which shape belonged to whom and explained the data translation process in more detail to explore how their perception of the artefacts might differ from or compare to their initial thoughts. In the following, I will discuss the initial findings from the practitioner’s responses and interactions during the ‘materialisation’ workshops.

**Emerging Threads**

Upon examining and analyzing the collected qualitative data from this exploration the following five threads emerged as points of further conversation and potential for future research.

*Encourage Discussion and Reflection on Technique*

Upon unveiling the fabricated artefacts and an initial excited response from the participants, ‘wow, lovely’ and ‘they are fabulous’, the differing shapes and their comparability between them encouraged participants to discuss, reason and compare the shapes amongst themselves and in relation to their craft techniques.

Purposefully not naming or highlighting the materialisations for each participant, the shapes were left open for interpretation and consideration, encouraging discussions about why one shape might be their own or another might be someone else’s based on their differences in crochet techniques. For example, one participant suggested that, ‘maybe this is yours because you twist more’. While another participant considered a shape as representative of her crochet style, ‘I think this one is mine, it’s quite dense’, with another disagreeing, ‘I don’t think that’s even enough for you’. This discussion led to a wider conversation about their different techniques and crochet styles from being more ‘jerky’ (jagged) to ‘pulling more’. In some cases leading to a comparison of their different personalities, ‘that’s the personality that she is’.

After I revealed which shape belonged to whom, the conversation about their techniques continued but went into more depth. Upon being asked about her
shape, ‘So why is yours like a C then?’, one participant went into more detail discussing and showing her technique: ‘because I put the wool on the wrong side of the hook. I wrap the wool around so I have to twist it to pull it over instead of sliding it behind.’ With others comparing this to another shape pointing out distinct differences in the form, e.g. ‘you don’t twist yours at all so you can see the difference’.

These shared, comparative conversations were mixed with more individual reflections on their practice. Participants were interpreting their shape by drawing on personal interpretations and their own perspective on their technique without directly comparing it to others.

One participant was explaining why her shape was fairly condensed: ‘I think that I probably do keep mine very much in one place […] keep it quite close and […] doesn’t really move very much’, while another was directly relating her movements to her shape, ‘the quicker I go the more jagged mine is’. With this, she was clearly referring to her shape rather than the actual crochet piece that she produced in a very neat and tidy fashion. This showed that the movements of the practitioners and the subsequently generated materialisations didn’t necessarily respond to the pieces of work in a direct way but highlighted that the movements of craft practice are of a more personal and individual nature.

The comparison and reasoning of the shapes highlighting differences in techniques was a continuous process throughout the workshop and raised awareness of techniques or what could be described as personal quirks, that the practitioners were unaware of before participating in this work. For example, one participant referred to her shape when remarking, ‘I didn’t know that I made big loopy bits’, but then went on to say, ‘but now, that I’ve looked at that I’m doing it a bit gentler now’. This conversation in particular showed that this work had an impact on their thinking about their own and other’s crochet techniques and it is also further hinted at the potential of this work for changing behaviour as the participant added, ‘I am now like thinking when I’m doing my wool. Like, I’m going around and out, I am now trying to see that picture when I’m doing it.’

Legibility versus Abstraction
During some of the discussions it was also noticeable that the abstract nature of the data translations for the tangible artefacts raised questions around legibility. The level of abstraction of the shapes and their creation was discussed by the participants with some not understanding how the shapes related to their movements asking, ‘why doesn’t it look more like crochet?’, highlighting how they were trying to make sense of how the shapes related visually and tangibly to the process and movements of crocheting. I was attempting to create shapes for the participants, which were not only directly representational of their crochet techniques but rather abstract provocations for conversation and meaning making.

Although some recognised their shapes early on, it proved more challenging to others. For example, one participant stated that, ‘I can’t see anything’, while others who seem to understand the shapes better were trying to explain the differences. Personally recognising their shapes prior to my explanation was also discussed as noted by one participant that, ‘it’s funny how you recognised yours’, which was explained with it was, ‘probably because it’s more symmetrical than the others’, which apparently was a general personal preference of this particular participant.

Generally, in these conversations the ambiguity of the shapes often encouraged associations in order to describe the shapes, for example a shape being described as a ‘moon’ or ‘crescent’ shape or one of the 3D prints as a ‘lost island’. The associations were ways for the participants to make sense of the differences and similarities of the shapes. Additionally, the participants did not only show an interest in the shapes themselves, but were also curious and inquisitive about the processes of translating data into generated shapes.

As mentioned above, questions of how the data was translated and why the shapes looked a certain way was initiated by the mysterious, concealed nature of the translation process. This led to conversations about my research practice and the participants becoming interested in the process of data translation itself, actively offering advice and criticism for future work.

For example, the similarities in size led participants to inquire how the programme was scaling, or more technically mapping, the data to generate the shapes. When explaining how the shapes were somewhat altered by the developed algorithm, they noted that it’s ‘hard to compare them then isn’t it if you’re changing the size of them’; and suggested, ‘it would be really good to see them all in actual size’. In that sense, they were becoming involved in the research process themselves, starting to make suggestions as to what changes to make and what to potentially try in future work. Furthermore, they agreed that a more interactive translation of data would be beneficial for the participants to assume a more active role in the whole process of making with their data. So although the abstract nature and uniqueness of the shapes did encourage comparison and conversation of the tangible artefacts, a more personal, participatory experience rather than abstract translation process should be explored further.

Materials Matter
With crochet being such a tangible and haptic craft experience, I considered the fabrication of the shapes in several different materials as an attempt to gain some insight into the material qualities of digitally fabricated artefacts in relation to craft practice. Although the discussion of the chosen materials in relation to their craft practice was brief, they did discuss the crochet materials I used to collect their
initial movement data and how this may have had an impact on their movement with it being different materials and tools to their usual practice. One participant noted, ‘I think it was harder because it was a bigger hook and bigger wool as well.’ This highlights how important the material aspects of craft practice are and that the choice of materials and tools is a very personal one for each practitioner.

By encouraging participants to select one or several artefacts to take with them as a souvenir, I hoped to instigate a discussion of the different materials and qualities. It was notable that participants did not choose the card or fabric artefacts but all selected one or several of the wood, acrylic and 3D printed artefacts. When discussing their material choices it became clear that their selection was something intangible and not conducted consciously. It was a more personal response or attraction towards certain materials.

However, all artefact choices fall into the category of more sturdy or rigid materials, in comparison to the card, paper or fabric that were not chosen. Equally another commonality between the chosen materials was a higher contrast and visibility of the data traces. This might be giving the shape more depth in comparison to the visually weaker traces on the card and fabric, which is particularly evident in the 3D printed version.

Although the highest contrast of all artefacts was the black and white print of the paths on card rather than then laser cut artefacts, which was not chosen by any of the participants as a souvenir. It became clear, when I prompted them to discuss their choice of material, that the inherent qualities of material were essential for their selection. One participant reasoned that with the translucent acrylic material ‘you have the light coming through so you can see more of the forms,’ while another’s motivation for choosing the wood shapes was ‘the thickness with those.’ Although there were difficulties in articulating their material choices, their selections still highlighted that there is value in (a) the quality of the material, (b) the visual nature of the traces and (c) the digitally fabricated artefacts themselves which lead to further conversation and appropriation of the shapes.

**Possibility for Appropriation**

While choosing the materials as their souvenirs, all participants were holding shapes up and comparing the different materials, considering what they would like to do with them. A range of potential future uses were discussed, for example one participant declared ‘I would wear that as a brooch,’ holding it onto her clothes to see what it would look like (see Image 5), while another noted that one participant’s artefact is ‘the best shape to wear.’

Other future uses included coasters and hair clips, whilst another participant was considering how she would like to appropriate the shape: ‘I’d like to stick flowers on there and wear it’, which directly related to her own craft practice, often working with embroidery and floral felt shapes.

With this in mind, revisiting the earlier discussion around abstraction, it can be emphasised here that the abstract nature of the forms were ambiguous enough for participants to inflect their own meaning and uses onto the artefacts to be more personally relevant than a prescribed use would have been. Thus, furthering the craft practitioners’ engagement with the artefact to potentially incorporate their artefact in their own work creatively. This is hinting at the potential such artefacts may hold to possibly be folded back into their craft practice, drawing a unique connection between the artefact and the making process which will be explored further in future work.

**Materialisation as Memento**

So far I have mainly focussed on discussing the conversational aspects of the data artefacts during the workshop itself. However, I would also like to consider the value of the artefacts beyond the duration of the workshop.

After asking what participants have done with the objects after the workshop, one participant mentioned that after showing the 3D print to her family she took the artefact to her studio as she finds the idea of 3D printing ‘inspirational’. She explained that she was using her 3D print to engage visitors to her studio in conversation about craft practice, mentioning that she ‘got to show people at the studio especially during the Art Tour and people were interested in the idea of transferring movement into a sculpture’.

This highlights, not only that the work had an impact on the participants’ thinking about her crochet technique, but the artefacts themselves have value beyond only being reflections on craft practice opening up a much wider range of conversations.
Another participant sent a picture of her artefact taking pride of place on her mantelpiece at home (see Image 6) and commented that it is ‘for me to feel proud of’, is showing that not only does the artefact carry personal meaning for her, but also her giving it a thoughtful and special place in her home. She went on to explain that she likes that the artefact ‘visualises a tradition and is written in secret crochet code’, which for her represents her ‘struggling and (more or less) succeeding to learn a skill I’d always admired and associated with my granny and mum’.

This shows how participants interpreted the shape in a very personally meaningful way relating to her practice and heritage. The same participant who earlier ‘couldn’t see anything’ in the data translations still had a very personal and meaningful relationship to her unique artefact. Her description of the artefact embodying her personal ‘secret crochet code’ that only she knows about, highlights how the data materialisations can become things in their own right. These personal responses to their own artefacts emphasises the materialisations’ potential to act as mementos of experiences that go beyond the workshop and reflections on craft practice, holding much stronger personal, even emotional meanings.

Combining and Following the Threads

In this paper I have shown early experiments and findings of how traces of the embodied processes of making can be translated into tangible artefacts to evoke conversation and reflections on craft practice. I have discussed this initial study of data materialisations in the context of craft practice as five emerging threads to indicate the potential and value of data translations into personal artefacts. In summary, let me draw out the main aspects of these findings to consider and highlight prospects for future research:

- By encouraging discussion and reflection through the generated materialisations, the practitioners acquired new knowledge about their own techniques as well as differences and similarities to others. It highlights the potential impact these shared conversations had on their thinking and their practice and how data materialisations can act as resources to facilitate such exchange.
- The level of abstraction in connection with the legibility of the data was an issue raised in relation to the craft practice itself. Although further work is necessary here, it also highlights that the practitioners entered a more mutual relationship with the researcher through becoming actively involved in the process and suggesting a more interactive, participatory approach for making data materialisations.
- Although it is common knowledge amongst craft practitioners that materials and materiality matter in craft practice, the importance and personal preference of such was raised in several conversations. In relation to the data materialisations several material characteristics were considered favourable, such as material thickness, translucency and intensity of data traces.
- The ambiguous nature of the generated artefacts encouraged imagination of potential future uses and opened up possibilities for personal appropriation, which hints at the potential that data materialisations may hold to be incorporated back into the practitioner’s own craft practice.
- Investigating the value and meaning of the data materialisations as mementos beyond the workshop itself showed that the artefacts had potential to become meaningful things in their own right rather than solely being byproducts of their craft practice for the purpose of research. They were not only used in wider conversations about art and craft practice, but also held more personal meaning and emotional connections to family and tradition as described by one participant, both highlighting the value of the ambiguous nature of the artefact as beneficial for personal attachment and facilitating conversations.

With the explorative nature of this work, I acknowledge that further work is necessary to fully understand the value, potential and issues of translating craft movements into tangible artefacts for reflection and meaning-making and I will expand on...
this by considering a number of key areas. For one, the relevance of the captured data and potentially different facets of data should be explored in connection to how it might influence the meaning and meaningfulness of these artefacts and the personal relationships participants develop. This work touches on novel ways to engage practitioners with uniquely personal data through tangible, material means with potential to build meaningful relationships, which I believe deserves further consideration in more general terms. There is potential to apply this method to making with data in other contexts, beyond the craft practice described here, as a way of engaging audiences in conversations, reflection and meaning making.

One of the main areas for further exploration is, however, a more interactive, experiential, real-time materialisation approach that could engage craft practitioners more actively in the overall process of making with their own data. Suggested by the participants themselves, it also mirrors Ingold’s (2013) perspective I’ve taken here, following Heidegger’s distinction between objects and things, that one has a more affectionate relationship to an artefact if one is more involved in the whole ‘lifecycle’ of an artefact through active participation in its making rather than having a passive relationship to mass-produced objects. Or as Ingold puts it, ‘To witness a thing is not to be locked out but to be invited in to the gathering’ (Ingold, p.85). In this case, it does not only encourage a more participatory approach to digital fabrication but also to the data capture, translation and making processes. With this in mind, this work has only scratched the surface of how these shared, participatory aspects of the making experience can be incorporated into artefacts as things.

I have shown here how giving transient making processes physicality can bring tacit aspects of craft practice into focus and initiate conversation. For that matter, it is important to note that the value and meaning of the artefacts or materialisations did arise out of the active process of engagement, comparison and discussion of the shared collection of artefacts amongst the participants in the group rather than being predetermined through isolated artefacts.

This meaning-making process is showing parallels to the shared and social nature of traditional craft practices, such as crochet, with an emphasis on the haptic qualities and materialities of the tangible artefacts. It highlights that digitally fabricated data materialisations can act as a resource for discussion and reflection, underlining the complexity and difficulty in understanding embodied interactions between craft practitioner and their materials. To that extent it is valuable to further investigate the social aspects of crochet practice and how these could inform data materialisations that can potentially be incorporated back into the craft practitioners’ work to enrich their craft practice as well as the craft object in itself.

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References

Bettina Nissen is an AHRC funded PhD Candidate in Digital Media at Culture Lab, Newcastle University in Newcastle Upon Tyne, UK. Nissen’s research is part of a bigger funded project, The Creative Exchange, which encourages, fosters and stimulates collaboration between Creative Industry and Arts and Humanities Academics. With her background in product design, Nissen’s design-led enquiry is looking at digital fabrication as a tool to engage new audiences in conversation, reflection and meaning-making. Her practice-based work is borrowing elements from data visualisation and generative design to embed digital fabrication within data making activities translating digital information into tangible form as personal souvenirs, evocative objects and meaningful artefacts.
This paper concerns the inaugural project of an initiative at Emily Carr University of Art and Design called the Centre for Applied Art and Material Production (CAAMP). CAAMP is dedicated to cultural inquiry regarding the contemporary circulation of images and objects, with a mission to promote the integration of applied art practices with contemporary art culture. Driven largely (but not solely) by curricular projects, this research centre aims to facilitate the production of knowledge through collaborative design and manufacture. As an added challenge, it seeks to bridge incisive academic investigation with the mass appeal of collectibles, commodity culture and the entertainment industry.

In this spirit, the designer toy industry serves as the framework for this paper and the first of CAAMP’s projects (Image 1). A full understanding of the project requires a bit of background on this industry and the subculture that supports it. It is a territory that has grown explosively over the last 15 years and yet maintains a niche of its own at the edge of mainstream. Designer toys, or urban vinyl, or art toys, as they are variously labeled, are not the kind of products one typically finds at stores selling conventional toys for the entertainment or socialization of children. In this sense, the designer toy is not a toy at all, but rather a collectible intended for adults. It is created from the designs of an artist, a designer or a collective, and most often mass-produced in modest numbers as a rotocast vinyl figure (though resins, fabrics and wood also have established a strong presence within the industry).

As they are born of artistic vision rather than massive production and merchandising, they are a category of object that clearly stands apart from other commercial toys. A potent streak running through designer toys and urban vinyl is characterized by the tendency to combine the innocent and endearing proportions of traditional toy design with edgy or adult subject matter that conservative parents would consider inappropriate for children. The phenomenon of designer toys took shape in the late 1990s as practitioners within an array of creative industries and subcultures turned their attentions to subverting traditional toy design. Its pioneers hailed from the music industry, street art and illustration. As the movement continued to grow, so did its affiliations with other creative industries and subcultures. From its earliest days, the designer toy and urban vinyl platform as a means of academic inquiry – an invitation to investigate our adaptive and/or conditional nature.

Keywords: Designer toys, ceramics, illustration, digital prototyping, artist multiple, slip casting.

Abstract
Collaboratively designed by students and faculty of the Illustration program at Emily Carr University, the Darwin project employs industrial ceramic processes but adopts the aesthetics and collaborative dynamics of the explosive ‘urban vinyl’ subculture. As a generic figurative form that lacks detail and invites transformation through surface design, Darwin appropriates the strategy of the designer toy ‘platform’, popularized by Toy2R’s Qee and KidRobot’s Dunny. The project involves glazed ceramic ‘blanks’ that are produced as identical multiples that are then offered to collaborators; each of whom provide a unique surface pattern to create a customized version of the product. Like his namesake, Darwin is all about adaptation, and offers an ideal opportunity for collaborative experimentation. Regardless of the creator’s experience with ceramic media, any digitized image can be applied and kiln-fired onto the form with specialized ceramic decals. Unlike the vinyl toys that inspired them, the Darwin figures are conceived and presented primarily as a form of academic inquiry — an invitation to investigate our adoptive and/or conditional nature.

The Darwin project aims to investigate how the collective and potentially disparate concerns of a community might be manifested symbolically or allegorically. This research project explores the ability of a collection of objects to communicate through their interrelation; a collection that does not strive for fixed meaning, but rather aims to act as a multiplicity of ciphers through which we might continuously revisit the complexities of a given question. The project advocates the ethics of localized production of designer toys, rather than their importation from overseas factories, and it democratizes the design of the objects through broad collaboration, while limiting the scale of production to demand. Though the project employs a formal vocabulary derived from plastics and animation, a much older lineage of allegorical figuration is evoked by its translation into ceramic material.
Vinyl movement has possessed, at its core, a highly collaborative spirit. The designer toy platform quickly rose to a position of prominence within this emerging field. Popularized by Toy2R's Qee and KidRobot's Munny, among others, a platform consists of a generic figurative form that lacks detail and thereby invites customization through surface design. This strategy affords the company that produces the objects two key opportunities. It can enlist any number of artists and designers to provide surface designs for limited or unlimited production of various iterations of a singular popular form, and it can also sell blanks, or figures with featureless surfaces, that the general public can purchase and customize themselves (Image 2).

In 'A Vinyl Platform for Dissent: Designer toys and character merchandising,' author Marc Steinberg (2010, p.209) argues that the 'urban vinyl' subculture represents a 'site of resistance to the contemporary circulation of images and things.' This article argues that the field represents 'a materially situated critique of the commercial practice of character merchandising,' stripping characters of their adherence to formula and branding, and the corporate entertainment franchising that governs that world. It is in this sense that Steinberg deems 'designer toys' (ibid) to be truly disruptive as they create and exploit gaps in normative cultural communication.

The designer toy platform represents the most aggressive challenge of all to the standardization of traditional character merchandising. By definition, all work created for a platform is collaborative in nature, and as Steinberg suggests, 'runs counter to one of the basic tenets of character merchandising: the presumed singularity and uniqueness of a given character's shape, color, and design' (ibid).

KidRobot is a company that has been particularly successful in this area, regularly commissioning new editions of a designer toy platform named Dunny, which are often released in a series that combines the work of various artists. One Dunny series of note is the Azteca II Series, introduced in 2011, which brought the work of Mexican artists together with that of Chicano artists living in the United States, in order to explore a common heritage across the border that separates them (Image 3). Other Dunny series have gathered together artists that share common experiences, thematic interests or nationality. The Azteca II Series represented a particularly fascinating exercise that went beyond the inherent subversion that fascinated Steinberg. A broad range of iconography was explored by the Azteca II artists. The series was given a uniquely provocative edge by the manner in which some artists opted to appropriate clichés or negative stereotypes of Mexican identity.

The Azteca II Series reveals the potential of the designer toy platform to investigate how the collective and potentially disparate concerns of a certain constituency might be manifested symbolically or allegorically. A series of such figures could in fact be considered a research tool, to be applied to complex questions that might be better understood if addressed in a plurality of interpretations. It struck me that an academic project could employ these means to explore the ability of a collection of objects to communicate through their interrelation. A collection that shares a certain kinship in its point of departure, but might offer poignancy in its divergence. A collection that also does not strive for clarity or fixed meaning, but rather offers the fragmented view of a prism. In this multiplicity of representation, we might continuously revisit the complexities of a given question.

Collaboratively designed by students and faculty of the Illustration program at Emily Carr University, the Darwin project is a response to that challenge. It employs ceramic processes but adopts the aesthetics and collaborative dynamics of the designer toy platform. As a generic figurative form that lacks detail and invites transformation through surface design, Darwin celebrates the slippage between form, surface and identity that Steinberg addresses, and chooses as its theme the examination of our own transformative nature. Though it functions unapologetically as a commercial product, each figure represents an invitation for a surface designer to investigate the adaptive nature of our existence. It offers the potential...
The Darwin project strives to build upon and expand the function of inquiry that is often latent in the designer toy. Cultural inquiry is here placed in the driver's seat, so to speak, as part of university primarily as academic investigation. Taking inspiration from the Dunny’s Azteca II Series in particular, the Darwin project is an experiment that explores the modification of a mutable object. It should be noted that a university studio such as ours, at Emily Carr, lacks the full capabilities for mass-production that an industrial ceramic facility might provide. Though we are able to produce identical multiples in modest numbers, our collaborators must work within limitations. Regardless of the designer’s experience with ceramic media, any digitized image can be applied and kiln-fired onto the figure with specialized ceramic decals, but the compound curves do present additional challenges to those who wish to wrap the entirety of the form with an uninterrupted image (and the ceramic overglaze printer we utilize does offer a narrower colour gamut than conventional CMYK). Like his namesake, the process of creating each Darwin is all about adaptation.

Designer toys are products that regularly traffic in absurd, pathological and taboo subject matter, and they frequently tackle their subjects in ways that can be socially insightful or just aggressively hedonistic. Often the figures are disruptive to dominant perceptions of propriety and decorum, but without positioning themselves clearly as either gratuitous irreverence or sly critique. In embracing this subculture within a university devoted to academic inquiry, our challenge is to generate work just as intuitively and impulsively, and to channel the development of those projects in ways that examine our collective production of images and consider its communal effect.

The Darwin experiment was conducted within the framework of a relatively young Illustration curriculum at Emily Carr University. This curricular area was introduced in 2009 as a new stream of study within a visual art degree program (recently reconstituted as the Audain School of Visual Art) that has been firmly rooted in the practice and culture of contemporary art, and its relationship to the larger program is still evolving. Because of a longstanding curricular emphasis that subjects mainstream mass-culture to rigorous critique, illustration students aiming to develop work for commercial markets must negotiate a set of objectives that can appear to be operating at cross-purposes. Contemporary design culture may have largely evolved beyond approaches that emphasize solutions to design problems within fixed systems (to now prioritize the questioning of the larger systems themselves), but the older paradigm continues to dominate many client-driven practices. That legacy can also appear to be at odds with the core priorities of contemporary art culture, which prizes the ability to problematize or to raise questions over the formulation of quick solutions.

This challenge is certainly not unique to Emily Carr University, as many institutions of higher education encompass both commercial and fine art, and must reconcile the distinct pragmatic considerations, audiences, and objectives of the two. In his essay ‘Expanding Illustration Design Studio Practice through Critical Reflection’, David Blaiklock articulately breaks down some of the tensions around criticality within the study of illustration as he addresses specific pedagogical strategies implemented at the University of South Australia in Adelaide. He advocates increased critical reflection that serves to ‘question assumptions’ beyond the customary prioritization of ‘judgments about the project outcome, design processes, visual techniques and production processes’ (Blaiklock, 2011, p.6).

Citing a wide array of thinkers on the subject, Blaiklock affirms the impressive degree of technical and dialogic reflection that underpins the practice of illustration, while noting the need to deepen the kind of reflexivity that questions the cultural or socio-political presumptions that might be endemic to mainstream media or markets – presumptions that might be overlooked within the industry itself. Indeed, it is often the fact that a professional illustrator is not often in a position to challenge the underlying ethics of a client’s product that undercuts the deeper examination (and suspicion) of implicit suggestions within images or narratives in a commercial context.

The framework of designer toys has unique value in regard to exercising criticality within illustrative practices. Though it would be a gross generalization to characterize any facet of illustration practice as being uniform in style or content, many professional applications do have distinct tendencies or favored methodologies. Editorial illustration is an area of practice that exhibits kinship with conceptual approaches prevalent in the contemporary art sphere, often celebrating images that remain open or even paradoxical in their meaning. In this regard, editorial illustration dovetails more easily with objectives common to contemporary art culture. Because such illustrations often aim to reflect the subtleties of debate, or serve to highlight contentious issues in politics or current affairs, they will ideally resist a comfortable resolution in the mind of the viewer. A concise visual metaphor might be the Art Director’s goal, but typically it is a graphic means to capture unresolved tension.

The entertainment industry, on the other hand, is rife with images and narratives that ultimately deliver neat resolution, regardless of whether they defy expectations en route, or question prevailing values. The territory of
designer toys holds exceptional promise in that it is highly commercialized and unrepentantly indulgent in its embrace of sheer entertainment and marketing, and yet its content is as slippery and ambiguous as editorial illustration—and often more so! This is evidenced in the frequent use of mashups in designer toys, which arrive at novel creations by casting familiar mass-culture references into new and entirely absurd contexts. Though these might originate as purely impulsive gestures, they occasionally deliver the unnerving disruption of a surrealist Exquisite Corpse, or result in insightful social critique.

It is incumbent upon academic programs specializing in illustration and animation, particularly here on North America’s West Coast, to both engage and question the role of entertainment industries. Designer toys offer an ideal laboratory for experimentation because they occupy a marginal space where corporate-controlled mass-entertainment and mass-market consumer goods are typically engaged outside of the logic or purpose that typically governs those territories.

Emily Carr University’s Centre for Applied Art and Material Production (CAAMP) evolved from an earlier research initiative, simply called Factory, developed at the University of Oregon (in Eugene) when I held a position there between 2000 and 2007. The emphasis of Factory was on ceramic tableware, and the potential of objects that possess a utilitarian function to explore social, cultural or ethical questions. The central mission was to adopt strategies of commercial commodity production, but to do so in the context of a contemporary art practice based upon inquiry.

Implied in the title is a challenge to engage the mass-produced object much as the mass-produced image was probed in Andy Warhol’s project, The Factory. Factory, first at the University of Oregon and subsequently at Emily Carr University, operated as a laboratory that integrated pedagogy, creative research and artistic production.

As key drivers of the exploration, participants took on a mission far broader than the concerns of ceramic practice alone as the project favoured a context-driven model of design practice and social engagement. Hinging largely on collaborations with local businesses and non-profit organizations, Factory embraced commodity culture as a means to both probe existing societal patterns of consumption and propose new ones. Production was generally confined to a small edition of objects, either limited (numbered, as with an edition of prints) or unlimited (whereby production could go on indefinitely, with an unspecified total number of objects), but this enabled us to stage local events involving a small public gathering, at which the products of our laboratory took center stage.

The goal was to create a microcosm of mass-consumption within which to examine the effects of our experiments. Past projects have involved local restaurants, a women’s shelter as well as non-profits dedicated to combating hunger and malnourishment and promoting clean water efforts in the developing world. The framework alternated between community service and entrepreneurship, but neither altruism nor the profit motive was allowed to distract the project from its underlying dedication to cultural inquiry regarding the contemporary circulation of images and objects.

The community-minded spirit of inquiry that fueled the Factory project has since been carried into CAAMP. The fact that Darwin involves the small-scale production of glazed porcelain blanks rather than the mass-produced vinyl objects that inspired the project, enriches the spirit of inquiry. The project embraces the ethics of localized production of designer toys, rather than their importation from overseas factories, and it democratizes the design of the objects through broad collaboration, while limiting the scale of production to demand.

CAAMP is a participant in a larger research cluster called Material Matters at Emily Carr University, which is dedicated to exploring innovative approaches to technology and materials, centered upon, but not limited to, 3D printing. Material Matters researcher Philip Robbins was a key participant in developing an innovative workflow that integrated digital technologies with legacy processes of ceramic production, and this has been a key aspect of the Darwin project.

Although the original prototype and the first iteration of Darwin were produced by traditional analog methods, subsequent iterations have benefited from the form’s recreation through digital prototyping and the use of 3D printing in the production of plaster molds that were used to cast the multiples. The efficiency of the molds remains less than ideal, but the goal is to further develop these and other hybrid methods to mitigate the steep learning curve inherent to traditional ceramic process. A combination of technologies could further enable newcomers to ceramic production (such as students of illustration) to play a key role in the objects’ design and production without the onerous demands on their time that would be required by the development of greater expertise with ceramic materials. A discussion of this materials-based research is discussed in greater detail in another paper presented at this conference by Philip Robbins, entitled ‘Material Matters: Hybridizing emergent digital methodologies across legacy creation ecosystems.’

The fact that this genre of object straddles the divide...
between art and design offers further pedagogical value. In his essay 'Vinyl Rules: Surrogate sculptures and the manufacture of identity', Carlo McCormick (2006) asserts that the designer toy hews to the lineage of the 'Artist Multiple' as much as (or more than) that of the toy. '[B]y lineage and legacy this is actually the kind of subgenre that belongs to the species of artists' multiples,' offers McCormick, as he draws a thread from contemporary vinyl toy designers back to luminary artists such as Marcel Duchamp and Joseph Beuys. In the vinyl industry, editions can be small in number or quite large, and individual objects can vary in scale from pocket-sized products sold in blind boxes to large one-off sculptures. This allows for a complex culture simultaneously operating within diverse economies, catering to audiences that include both casual shoppers and specialized collectors.

In addition to its connection to the artist multiple, there are deeper historical traces that are perhaps still more intriguing. The Darwin experiment harnesses the formal vocabularies and themes that are typical of vinyl designer toys and translates them into ceramic materials. One could argue that the success of urban vinyl lies largely in the tensions created by the uneasy integration of the child-like playfulness of the toy and the anachronistic, streetwise or surreal subject matter. If so, the layering of yet another symbolically charged element— that of the ceramic figurine and its historical and material connotations— offers the opportunity to explore dynamics of even richer cultural complexity.

Ceramic figurines hold an impressive legacy, from the terracottas of Ancient Rome, to the stoneware of the Tang dynasty and the porcelain of 17th century European aristocracy. The mainstream production of ceramic figurines might have long since given way to the crassly sentimental or the clichéd and kitsch objects that fill today’s second-hand shops, but the enduring appeal of miniature figuration is undeniable. The presence of narrative miniature figures in the home has been widespread throughout human history, and in this respect vinyl toy culture can draw its lineage from ceramic miniatures of old. The Darwin project’s shift in material from vinyl to ceramics serves to bridge this historical thread, and reflects a timeless predilection for domestic allegorical figures that seems to be curiously hardwired into us, across geographies and time periods.

The design of the Darwin form itself sought to harness the sleek reductive stylization of contemporary toy production, but to eschew caricature or whimsy in order to trigger a wider set of associations. The sleek reductive formal aesthetics born of contemporary industrial processes may be the dominant formal vocabulary of the artifacts of our time (serving as a sensory form of lingua franca), but it also echoes 20th century modernist abstraction in sculpture as well as pre-modern formal traditions of Pre-Columbian Mexico or Inuit stone and ivory figuration. The streamlined aesthetic of contemporary product design is an aesthetic that permeates our culture so comprehensively that we might fail to recognize its rhetorical impact when applied to the narrative figure.

While resin, plushies made from fabrics, and even wood, have all grown in popularity, traditional ceramics remains relatively under-explored in the field of designer toys. Today’s vinyl collectibles, however, have much in common with porcelain figurines as they functioned in their own heyday. Seventeenth-century porcelain figuration, like contemporary high-end vinyl toys, offered a seductive new material fetishized by collectors. Each material gave birth to a genre of allegorical figuration whose production was perfected in the Far East, and would grow into a phenomenon that would take hold of imaginations worldwide. In light of this, it is only natural that contemporary ceramics should reassert its relevance and adopt a leading role alongside vinyl, as the antecedent of the designer toy.

When the time-honored medium of ceramics adopts a formal vocabulary that is typically associated with plastics and animation, it can acquire an uncommon resonance. As thematically or stylistically contemporary as any individual surface design might be, each Darwin figure possesses an undercurrent of vulnerability and nostalgia that is manifested in the ceramic material itself. This perhaps encourages a deeper reflection on the role of the figurine as an artifact that can conjure obsessiveness, even in an age of boundless virtual entertainment.

In Society of the Spectacle, the French theorist and cultural critic Guy Debord (1967) writes: ‘[C]onsciousness of Desire and desire for consciousness are the same project’. More than a clever turn of a phrase, the statement asserts that higher knowledge will come from reckoning with our deepest impulses, however base they may seem, not by safely rising above them. Those of us who teach in the arts at academic institutions would be wise to take heed. Debord’s words suggest a methodology wherein commercial practices for mass audiences fully embrace deepened critical reflexivity and poetic inquiry. In this vision, distinctions between contemporary art practices and applied commercial practices might even begin to seem inconsequential. The quote succinctly captures the spirit with which the Darwin project was undertaken, and I believe it can serve as a guiding light for any who aspire to a comprehensive engagement of visual culture, high and low.

**Individual Darwin Designs**

Min Joo (M.J.) Hur was a member of the team that collaboratively designed the original form—the platform itself. One of Hur’s Darwin surface designs playfully merges the architecture of the church with contemporary anthropomorphic character design (Image 5). Class, taste and status are challenged in the resulting mashup by placing the two on level ground. The incongruity upsets the narratives and rhetoric typically associated with both animal fables and
institutionalized religion. Given the project’s context of Darwinian questions, there is perhaps also an implicit nod to the longstanding friction between scripture and evolutionary science.

The grand prize for a 2012 competition for additional Darwin surface designs, which consisted of CAAMP’s production of an edition of six 12-inch figures, was awarded to Amelia Butcher, whose imagery reclaims the stereotype of the witch (Image 6). Once burned at the stake, the witch featured on this Darwin now lights her own fires at will, and delights in the kind of ambiguous identity that challenges patriarchal establishments.

In the same competition, Patrick Wong’s design was also awarded a prize. His Darwin is inspired by an essay titled ‘The Ring,’ in which French theorist Roland Barthes proposed that wrestling in 19th century France was a spectacle that reflected complex notions of public justice. Wong’s Darwin bridges high and low culture, reminding us that the entertainment we consume is laden with deeper subtexts (Image 7).

The first artist unaffiliated with Emily Carr University to be invited to submit a design for the project was Michael Salter. Salter serves up a Darwin covered with icons, he has developed over the years, on the theme of animals (Image 8). Loaded with psychic dissonance, his reductive, graphic approach suggests banal and trivial commercial signage, but instead offers dark and irrational glimpses of interspecies tension, including predation, extinction, anthropomorphism, adaptation and mutation.

Philip Robbins and I collaborated on a Darwin surface design commemorating the themes of the ‘All Makers Now?’ conference. This self-referential version offers a Darwin that is emblazoned with a digital wireframe version of itself, reflecting the migration of our identities into the virtual realm. A playfully existential iteration, it hints at the conference’s overarching concern – the reconciliation of virtual and material manifestation – and invites consideration of a broad set of attendant questions around authenticity, value and accessibility.

References

Justin Novak is Director of the Centre for Applied Art and Material Production (CAAMP) (www.campsite.ca) and Associate Professor in the Faculty of Visual Art and Material Practice, Emily Carr University of Art & Design, Vancouver. The DARWIN platform was collaboratively conceived in the Fall of 2011 by a creative team that consisted of an advanced Illustration class at Emily Carr University, its instructor and a teaching assistant. The group was comprised of Brad Allen, Dianne Almond, Hoe Jin An, Cathleen Chow, Hyeun Chung, Min Jon (M.J.) Hur, Mark Illing, Ainsley Jasper, Pierce Jordan, Soo Min Lee, Nicole Majcher, April Mihé, Jieun Min, Justin Novak, Joanne Oh, Sterling Richter, Jen Uy, Alison Vogelaar and Emma Walter. Fellow CAAMP Researcher Philip Robbins was instrumental in the digital prototyping and of the form, which further refined the design.
Entry: Digital objects and the (dis)placement of knowledge

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Introduction

New digital technologies and networks offer novel opportunities to communicate with others. They also change the transfer of knowledge between domains. This is true of craft as much as it is of other fields. For example, Mike Press writes that the ‘research turn’ in art and design has led to new relationships and values for craft as knowledge, beyond the world of craft itself, and that digital technology is playing a crucial role in this (Press, 2007, p. 255).

During a three and a half week artist residency in India in 2010, I worked on making a film, Entry, that when screened back to participants on the day of my departure, produced a range of responses from those who were filmed, and those of us visiting from the UK. These responses precipitated the question underlying this paper: is craft, with its relationship to bodily intelligence as well as its recent performative turn, in danger of being diminished as much as built up, if cut free from local intelligence and narratives? Perhaps it is important to say at this point, that while I was in Ahmedabad as part of a group of makers and am a (film)maker, this question reflects too certain anthropological ways of thinking.

During that first screening of Entry there was more interest from the Indian participants in the rushes than in the finished film. An unexpected misunderstanding occurred about what would become of this material. One of the people who had taken part in the film had asked me to put all the rushes onto a DVD for him, but the rendering did not complete in time and I only had dvds of the finished film, promising the other material (film)maker, this question reflects too certain anthropological ways of thinking.

Once uploaded to digital platforms and sent around the world, the trademark cycle decorated with garlands. A group of children spontaneously breaking into a garba and a trademark cycle decorated with garlands. ‘Entry’ was made during a three and a half week research residency in Dhal ni Pol, one of 600 pols located in the old city of Ahmedabad. It depicted a playful community-focused response to a small ‘theatrical’ doorway set up by the artists in a public space, decorated by the participants with ceramic flowers. In the finished film we witness the everyday aesthetics of this part of Ahmedabad’s old city: a mother gently oiling the hair of the child, a group of children spontaneously breaking into a garba and a trademark cycle decorated with garlands.

Abstract

New digital technologies and networks offer an unrivalled opportunity to communicate with others. But these same technologies also allow for ‘the transfer of this knowledge out of the domain in which it is generated’ (Leach, 2012, p.255). Does the digital increase ethical and social implications for craft of this transfer of knowledge, particularly given craft’s long history of bodily intelligence, which traditionally makes it resistant to abstraction and transfer? Or does the digital rather reframe existing assumptions about craft, and its relationships to people and places? This question arises from a project that in apparently transferring knowledge from a ‘real’ domain to a ‘virtual’ one via a digital film and digital platforms, produced different responses from the communities involved – those who were filmed and the artists. ‘Entry’ was made during a three and a half week research residency in Dhal ni Pol, one of 600 pols located in the old city of Ahmedabad. It depicted a playful community-focused response to a small ‘theatrical’ doorway set up by the artists in a public space, decorated by the participants with ceramic flowers. In the finished film we witness the everyday aesthetics of this part of Ahmedabad’s old city: a mother gently oiling the hair of the child, a group of children spontaneously breaking into a garba and a trademark cycle decorated with garlands.

As well as raising questions about the abstracting effect of digital technologies on craft as bodily intelligence, this paper charts the development of ethical considerations, from the outset of the project, to its completion.

Keywords: Craft, film, displaced knowledge.
**Dhal ni Pol**

The film *Entry* was made in Dhal ni Pol, one of 600 pols located in the old city of Ahmedabad. Pols are high density neighbourhoods that were once homogeneous communities associated with different castes, although today they are increasingly heterogeneous. Historically pols had one main street with lanes branching off either side, and walls and gates barred at night. Today, the narrow streets, the out-dated services and the dilapidated state of many buildings are contributing to out-migration from the east to the west side of the city (modern Ahmedabad) which boasts newer dwellings and infrastructure.

During the residency with CJ O’Neill, Steve Dixon, Lokesh Ghai and Palak Chitaliya, we made relationships with our Dhal ni Pol neighbours. The project was part of the Ahmedabad International Arts Festival and received coverage via several English and Gujarati articles in local and national papers. In other words, it was already highly mediated.

My own part of the residency culminated in a playful, improvised meeting between my presence with a camera and the residents’ daily making activities, with *making* thought of as an everyday cultural creativity highlighting social relationships. A camera set at a fixed point from a doorway that was built for the purpose, placed in a square used by the moped mechanic Daya, provided the catalyst for these playful encounters. Notices were put on blackboards around the pol inviting people to come and interact around the door and be part of the film. Information in Gujarati was provided on sheets handed out to residents and passersby on the day. The video camera recorded people’s interactions with each other, with us and with the door. CJ took still shots, providing a visual invitation to people to pose and be photographed.

One week after filming the result was shown to a large crowd of residents in the same space where it had been recorded. On my return to the UK, I wrote an account of that night:

*The Last Night*

As I stand up from where I have been crouching by the projector box, Aadi appears unexpectedly at my shoulder.

‘Where are they?’ he demands. ‘Everything you film, I told you! Everything!’

‘You mean the dvds?’ I say, ‘here, they are here’.

I bend down, pulling out of my camera bag the small pile of discs onto which I have burnt the film.

‘I couldn’t get all the rushes to fit onto one dvd so this is just the edited film I showed tonight and ...’

I trail off, Aadi’s face is a few inches from mine. He is shouting at me in Gujarati. I do not understand, but I think he is saying that I have come and found something precious and like others before me, I am only interested in taking it away.

As I take a step back, Dayabhai materialises from nowhere, grabs Aadi by his shirt and starts remonstrating with him, his voice rising to a shrill scream. For a moment, I have a sudden impulse to pick up the bag containing all my equipment and tapes and shove it into Aadi’s hands saying ‘Fine! Have it, have it all!’ But glancing in the direction of the women on the otla, and glimpsing Steve, CJ and Palak, breaks this momentary fantasy and I know that whatever I am feeling, I must feign ignorance, publicly erase what I have just seen by turning away.

I return to packing up the equipment and when I glance up again the men have let go of one another. Aadi has retreated to the edge of the chok. He stands there next to a small group of children who sit silently on mopeds, all of them staring at me.

Gathering up the last of my bags I prepare myself to say goodbye to Daya and his family. But as I do, I see that the women who have been sitting on the otla are now moving towards me in unison, flowing, almost rolling like a human tide.

These are people I have smiled at and greeted politely as I’ve walked past them during my time in the Pol, who I have danced alongside on several nights, but who I do not know, other than to say thank you when they offered me water and tea after dancing gerba each night. They encircle me now, taking my hands, apologising in English, which they haven’t used with me before, and which I didn’t know they could speak when I sat with them in the hot night.

‘We are sorry, so very, very sorry,’ they say. ‘No, no, its me who should be sorry. I’m so sorry! I will send the dvds, I really will’.

‘Where do you live?’ ‘One woman asks me? ‘I have a school. Please come there and film. When are you leaving? Please come to my school and my house’.

CJ, Steve, Palak and Palak’s husband are here beside me now and we begin to walk out of the chok, to go back to the house. As we approach Aadi, I look him in the eyes and he raises his hand, ‘Bye, Amanda’. I take a few steps closer and we look at each other for another moment or so, and then he stretches out his hand and I stretch out mine and we shake and say goodbye.

**Appropriation**

The material was quickly supplied via the post, but this moment of high tension revealed how at the point of leaving, I was seen to be appropriating something that up until then there had been no obvious dispute about. When I returned a year on to see how the
project was now viewed, and to speak further to Aadi, I found he was away. But Daya told me that Aadi had only been angry because he assumed I was going to sell the film and make a huge amount of money. I confirmed that I had made no money from the film, but I also made it clear that seen as knowledge, the film had most likely enhanced my academic career.

In fact, it appeared from what Daya said, that overall the project had engendered feelings of unity. A questionnaire carried out a few weeks later by Palak and administered to 20 people confirmed this. The following opinions were not untypical and were given in answer to questions about the effect, if any, of the project, as well as the motivations behind people’s willingness to take part in something initiated by outsiders:

There was a great change in the unity of the people. And my good values were also seen on screen.

According to India’s culture we help people. We don’t categorize them into familiar and unfamiliar people.

I am a teacher who is soon going to retire. After retirement I wanted to teach some things to the people of this pol and I am amused that what I wanted to do was done by a foreigner.

Abstraction, Knowledge and the Digital

But whatever the opinions about the project one year on, uploaded to digital platforms, the film removed everyday concrete experiences from the relationships in which they were embedded. This abstraction represents a good fit with the idea of knowledge as something whose efficacy increases in direct proportion to its independence from local contexts. Yet, at the same time, while we could argue that abstraction is increased by digital technologies, it is also important to recognise that abstraction in the mediation of social relations is far from new.

Anthropologist Keith Hart, cited in Miller and Horst’s book Digital Anthropology, points out that money accomplished something very similar. Exchange became more distant from face-to-face transaction. It focused on equivalence, calculation and the quantitative as, opposed to human and social consequence: (Hart, 2000, pp. 280-287, in Miller & Horst, 2012). Hart saw the potential for liberation in this and suggested reuniting money with social relations through grassroots schemes such as LETS.

Miller and Horst, on the other hand, emphasize the extent to which social relations continue and can even be enhanced, by these abstractions (ibid.).

The screening and the follow up visit certainly provided learning points for future projects that included the goal of better communication in any future research. But it was the ethos of craft and place, rather than the ethics of the project per se, that left me wondering. I had, after all, faced similar dilemmas before about what it means to abstract experience. This is the bread and butter of anthropology and something the anthropologist thinks about much of the time, though perhaps doesn’t ever completely solve. The speed of production allowed by the laptop and the digital camera, and the projector we hired, and later, the platform where the film resides, led me to question my own assumptions about the digital as a potentially alienating phenomenon, and about the danger of this craft as a set of material practices tied to real places through particular relations, bodies and materials.

Craft and Place

Augé suggests that place is an invention, but one which nevertheless convinces us. What he calls ‘anthropological place’ rests on a shared belief in the centrality to places of identity, relations and history. But he suggests this has been changed by supermodernity, and as part of this, by new media. Supermodern, or as he would describe it, non-places, no longer integrate earlier places, instead these are listed, classified, promoted to the status of ‘places of memory’ (1995, p.78). Non-place does not allow for an experience of society precisely located in time and space, but only for an experience of the solitary individuality combined with non-human mediation.

Craft, by many accounts, once evoked a similar set of relationships to those of Augé’s anthropological place. Craft of the kind described by Sennett (2008), Pye (1995) and Dormer (1997), is involved in relations with materials and others; it has deep history and operates through heterogeneous identities. Digital craft objects, despite their materiality, could be argued to be going in the direction of non-places. Disrupting the connection of things to precisely located times and places through their removal from those kinds of environmentally rooted relations, silently witnessing, but not synthesising, past and present, and not integrating with anything.

So despite abstraction being an historical fact of human life, is it possible to say that craft is indeed in danger of being diminished as much as built up if cut free from local intelligence and narratives? The question is a perplexing one. As could be argued with place, craft is perhaps also an invention, if what we mean by it – what I was imagining about it before doing this research – was something that resisted alienation and abstraction. The residency revealed that digital technology cuts both ways – it allowed me to work closely with others such as Palak who translated
the speech on the film and emailed it to me. It enabled me to edit and render the film, and get immediate reactions from those within it. And I managed to give people copies of the film the night I left and to communicate with them afterwards via email and skype, all of which brought us into closer contact and allowed this to be maintained. Later, I sent a flip camera, at Daya’s request, so that he and his close neighbours could film their rituals. Using the camera in association with a laptop owned by his nephew. But none of this was problem free. While the misunderstanding could not be attributed only to the abstracting tendencies of the digital (human life has always been highly mediated), the digital, I reflected, did change our encounters with our hosts, both shrinking distance (the film had been made and delivered in one place in a short amount of time), and increasing the speed of possible abstraction and extraction. The speed meant that our relationships with people were intense but not in-depth; there were difficulties with the flip camera that were hard to resolve from the UK, and there was of course, as described above, the misunderstanding around what was and was not possible in handing over the material in the time available.

Conclusion
It could be argued that what is changed by digital technology are not the core (anthropological) issues of a here and an elsewhere, or of whether or not knowledge is appropriated from one context and placed in another, but of how that opening and closing of social space, how the regulation of proximity and distance between people and lifeworlds is reconfigured, and the effects this has.

In the making of Entry, what seemed most remarkable was not so much that the technologies abstracted knowledge (writing a book about fieldwork experiences or craft objects does the same thing, indeed, firing a pot could be seen as a form of abstraction of place relationships), but how these abstracting actions of the digital were both potential vehicles of misunderstanding, and channels that could, as Miller and Horsch suggest, be resolutely resocialised (2012). The distance between me and people I filmed continued to be negotiated in ways that felt relatively familiar; with both sides regulating the relationship in ways that felt necessary to them. But the abstraction that was in a sense digitally augmented did have some consequences. Going back to the example of money and using this as an analogy, we can say that money transfers made possible by digital technologies that migrants use to send money home, do not mean migrant workers are not being oppressed and taken advantage of. Similarly, the participation allowed by digital technologies in production processes does not, in and of itself, alleviate inequalities or substitute true collaboration for exploitation.

Nevertheless, by staging Entry as an encounter, I wanted to show something of the improvised quality of the relationship between myself and people in Dhal ni Pol and to do so in a way that recognized that this encounter was framed not only materially by a door but also by a framing mode of production. The abstraction of difference into ones and zeros can be thought about in many ways. What I am suggesting here is that we use it to revisit our assumptions about place and craft. These are less facts, than invented categories that mark particular claims to knowledge. This is not to criticize invention (it is what human beings do) but it is to suggest that the digital not only offers opportunities for novelty, but allows us to review and revisit things we thought we knew.

References

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Hybridizing Emergent Digital Methodologies Across Legacy Creation Ecosystems

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Abstract

Material Matters – a research cluster within the Intersections Digital Studios of Emily Carr University – is exploring new digital technologies as an analogue to traditional methods and materials. As technologies become less expensive, more powerful and more pervasive they diffuse into a wider range of opportunities. As new means of creative production emerge, they intersect with established practice. Material Matters examines these points of contact. 3D printing is an emergent digital technology experiencing explosive growth; a proliferation of applications and technologies is multiplying across a very broad spectrum of activity. As the technology matures and disseminates, the 3D printing ecosystem grows and diversifies, and avenues for innovation proliferate. Material Matters is examining a diversity of conceptually interlinked inquiries framed by this new production platform. We are developing alternate pathways to object making that conflates the new digital opportunity with the inherent strength of legacy process. Conceived as symbiotic methods, rather than discrete, self-contained systems, we are examining how new technological means can interconnect and carry forward legacy process rather than simply supplanting it.

Keywords: Cost, 3D printing, legacy process, tacit knowledge, metal casting, slip casting.

Background

Recent years have witnessed a strong consolidation of technology and service with wide commercial market speculation on this potentially revolutionary wave of manufacturing or DDM (Direct Digital Manufacturing) (Singer, et al., 2011). Consolidation of the commercial market is made doubly evident by the recent mergers of the major North American commercial 3D print technology manufacturers and suppliers; 3DSystems and Z-Corp, and most recently; Stratasys and Objet (Hurst, 2013). These companies previously defined the main pillars of the North American commercial market’s share of 3D print service, technology and material systems.

Concurrent to this market based consolidation, open source additive manufacturing technologies, which are built upon an extremely fluid digital infrastructure allowing an unprecedented level of public participation and interaction are developing at a rapid pace. Powerful computer systems, affordable, full-featured 3D modeling programs, and high-speed communications networks allow for the design, production, sharing and refinement of any aspect of 3D printing’s architecture. As a result, an open-source community is driving the demand, development and distribution of a broad spectrum of inexpensive, high-resolution 3D printing technology.

Easily slotting into a home workshop, a studio, an office or emergent make-space, 3D printers have equipped the eager, engaged practitioner with a diversity of means for 3D form production. Further, Open-Source Appropriate Technology (OSAT) (Pearce, et al., 2012, pp. 17-29) and the widespread search for increasing economy in material cost, selection and ecological impact are rapidly re-defining what it means to have a sustainable, small-scale, personal production platform.

This proliferation of 3D printing technologies is leveraged by the inherent simplicity of its underlying premise: (1.) the processing of virtual, 3D, digital objects into slices and (2.) the accurate, sequential printing of these slices. Objects of nearly any complexity are recreated physically, layer-by-layer, utilizing FDM (Fused Deposition Modeling- plastic filament), SLS (Selective Laser Sintering-laser melted powdered substrates), SLA (Stereolithography – UV curable resins), LOM (Laminate Object Manufacturing – thin foils and papers) and 3DP (3D printing – powders set with printed binders). Each of these genres of printing have been championed by various
commercial entities, and though built upon the original simple premise of slicing and outputting, commercial machines have come to represent the pinnacle of accuracy, reliability and resolution, but at a cost.

To date, commercial machines have ranged from expensive to extraordinarily expensive. Commercial machines have tended to target large, and well funded, industrial market segments such as the automotive industry, aerospace, architecture and industrial design. Furthermore, 3D printing consumables (the materials that actually comprise the 3D print) have typically cost hundreds of dollars per pound/gallon regardless of the printer type. This cost structure has acted as a significant impediment for a broad spectrum of potential users as the capabilities of the technology are directly impacted by the overall expense of the printed object. The more expensive an object is to output it becomes less likely to be created.

The first research objectives this papers seeks to illustrate, explore the ways of capitalizing on the strengths of the previously mentioned communities: the burgeoning open source with its hands-on, egalitarian and highly accessible developments, and the parallel advancements within the high quality, closed source, for profit, commercial sector, combining them to produce accessible, high quality results at the lowest cost.

The initial objective of this research sought to replicate commercial 3D printable consumables for powder and binder based printing (3DP), utilizing a relatively inexpensive, and somewhat obsolete, Zcorp 310 printer (the 310 offers the identical mechanical functionality of higher end 3DP machines but with a comparatively limited feature set), and materials that are readily available at low cost. The primary advantage of hacking 3DP is that it utilizes some of the most straightforward printing materials available and does not require the complex production of specialized filaments (FDM), exotic photo-polymers (SLA) or difficult to manufacture powdered metals and plastics (SLS).

The second objective of this research is to explore the new methodological pathways created as the cost barriers inherent to 3D printing are reduced. Inexpensive, plaster based, printed objects not only allows for the creation of more or larger scale editions but also enables the production of objects of very different function – objects that begin to interact with existing ways of making.

**Objective One: Reformulate commercial consumables to drastically reduce cost**

Through an inference of the constituents of commercial powder-based consumables (gypsum based, hygroscopic (moisture attracting), easily screedable, strong green strength, high resolution output) a test regime was initiated to systematically replicate these characteristics. Initially, a baseline printable material was examined to investigate the viability of US Gypsum’s ‘Hydroperm’ plaster. This initial work builds on the pioneering research by Dr. Mark Ganter at the Open3DP lab at the University of Washington. Hydroperm has a number of desirable characteristics: it is readily available at a relatively low cost; it is a plaster based material that replicates the fundamental characteristics of commercial 3DP materials; and it has both absorbent and refractory characteristics. By itself, Hydroperm, though printable, produces less than satisfactory results. A fundamental characteristic of 3DP printing is the systematic, predictable transportation and deposition of a thin, flat layer of powdered material from a supply reservoir to a build reservoir via a rotating spreader bar. Hydroperm can be mechanically transported from one of these reservoirs to the other, but with random inconsistencies. Periodically, as material is collected in the supply reservoir and pushed to the build reservoir, it interacts with the previously deposited layers beneath it, dragging them out of position. This dragging may be repaired by a subsequent pass of the spreader bar or may recur in the same or other locations(s), producing objects with incomplete edges and unsatisfactory surfaces. Despite these inconsistencies, initial results did show that it is possible to print off the shelf materials directly, with no prior reformulation, but not to a standard that matches the surface resolution or reliability of commercial materials.

This issue of spreadability is partially the result of plaster’s cohesive characteristics as plaster, in its powdered state, wants to aggregate or clump to some degree. A solution to this clumpyness was found within the food processing industry. Many dry, fine-grained foodstuffs tend to stick to themselves during processing, creating difficulties for material handling. Calcium carbonate is employed as a food grade anti-caking agent to improve flow characteristics. Fortuitously for Emily Carr, as an Art and Design institution, it is also used extensively within a multitude of ceramics processes as an important and inexpensive constituent in clays and glazes. The addition of calcium carbonate to Hydroperm produces
a more predictable, free-flowing transportation and deposition of the powder.

Objects printed with a combination of Hydropersm and calcium carbonate produce outputs with predictable spread characteristics and relatively high surface qualities, but with relatively low green strength (the robustness of an object after printing but before final infiltration with waxes or adhesives). A solution also came from a food grade material – Maltodextrin.

Maltodextrin, a fine-grained sugar used in the brewing industry, adds considerably to green strength and resolution. Maltodextrin’s small particle size allow it to evenly diffuse through the hydropersm/calcium carbonate powder, creating three positive, interrelated scenarios:

1. Sugar is highly hygroscopic and readily accepts the printed binder as it is being applied.
2. Sugar liquefies and gels relatively quickly, thus holding the binder in place, and preventing excessive wicking into adjacent material.
3. As sugar dries it recrystallizes, forming a relatively firm matrix within and between printed layers allowing for strong green strength to develop.

The combination of these three constituents – Hydropersm, calcium carbonate and maltodextrin – produced a workable material with good spreadability, relatively high resolution and good green strength. At this point a test regime was initiated to determine an optimal ratio of constituents.

Through a series of 75 iterations a powder formulation was devised that closely replicates commercial powder’s characteristics but at a considerable reduction in cost. Commercial materials for 3DP based printing typically cost in the range of $50 a pound, this reformulated material, using readily available and inexpensive constituents, costs in the range of .50¢ a pound. This 20X reduction in cost has enabled the production of cost effective objects much more readily and at a much larger scale than was previously financially feasible and enabled the examination of an entirely different class of objects that explore questions of complementary production methods and hybridized digital workflows.

Objective Two: Integration with legacy process

The second trajectory of this research examines how the disruptive capacity of inexpensive object printing can be harnessed as a way to interconnect new digital methods with legacy processes (ceramic slip casting and non-ferrous metal casting).

Relatively large moulds for casting can now be printed affordably, creating a new type of digital workflow that jumps directly from the virtual (the digital model) to the actual (the cast-able mould) with no intervening steps. The moulds printed with this new powder formulation display two distinct and important characteristics: they are hygroscopic (they want to absorb moisture) and they are refractory (they can withstand high heat). These characteristics have allowed two streams of inquiry to emerge.

Ceramic Slip Casting
Ceramic slip casting is an artisanal and industrial process with a long history which is still very much in evidence within contemporary ceramic production. At its most fundamental, slip casting involves the introduction of liquid clay (slip) into a dry plaster mould such that the dry plaster pulls excess moisture from the slip until it has solidified enough to be removed from the mould and remain self supporting in preparation for final drying and initial firing. Mould-making has traditionally been a complex and time-consuming process involving multiple steps tied to the time sensitive application of tools and materials. Digital mould-making considerably shifts this workflow.

Within this digital process, the original and the mould are entirely designed on the computer; there is no physical master model. All the required geometry that enables the slip to flow into and out of the mould, that allows the mould to release properly from the casting and that allows to mould pieces to fit together accurately, are created in one closely interrelated,
Continuous process. The mould is then simply printed, de-powdered, set with water and dried in preparation for casting.

Non-ferrous Metal Casting

Metal casting is an ancient process that involves the introduction of liquid metals at high temperatures into a plaster based mould; traditionally it is a highly complex and labour intensive process with multiple critically interconnected steps. The creation of cast metal objects typically entails:

1. The making of an original form.
2. The creation of a mould of this original object.
3. The production of wax copy(s) from this mould.
4. The preparation of the wax object for casting (sprueing up).
5. The investing of the wax in a plaster/sand matrix.
6. The burning out of the wax from the plaster investment.
7. The casting of the metal into the void created by the burnt out wax.

The creation of cast-able, digitally printed moulds enables the reduction of the above seven steps down to two. In the digital metal casting workflow, the object, the mould, the channels for the molten metal to flow through and the channels for expanding gasses to escape, are all created in one digitally mediated process. There is no need for a physical original, wax copies or burning out. Once the digital content is created the mould is simply printed, de-powdered and cast.

Conclusion

Digital moulds have multiple specific characteristics: they can display complex geometries that are difficult or impossible to create manually; they can be scaled, distorted, multiplied and edited at will; they can be used for extremely different types of cast-able materials (metal, ceramic); and moulds need no longer be physically stored as they can be easily recreated on demand, and are now inexpensive to produce.

Importantly, these developments help create the conditions that invite the hybridization of the traditional with the digital. Combining methodologies enables 3D printing to transition away from outputting expensive facsimiles (plastic or plasters prototypes) to producing cost effective end of line objects in true life materials. Furthermore, this shift creates a framework for the reevaluation of the relationship between tacit making knowledge and digitally mediated processes.

3D printing, in its typical manifestation, can be a somewhat hermetic experience. There is a distinct separation between the maker and what is being made. Objects can display wildly complex geometries but:

"[T]he 3D printing process involves laying down material in a new way that bears little relation to the processes that have in the past been used to create artifacts in a familiar manner. (Hoskins, 2014)"

As a result, 3D printed objects can display more evidence of the capability of the underlying technology than the nuances of the maker. Tacit material knowledge is redundant in a process that is completely separated from it, but the result can be objects that:

"[A]t best look as though they are using a very specific technology in itself and not a means of communicating an idea through an appropriate tool. (ibid.)"

By inserting the tool of 3D printing within existing method, an interactive relationship is established between legacy process, personal experience and the digital technology. This relationship between emergent digital capabilities, tacit material knowledge and traditional ways of making, was initially presented at the 'All Makers Now?' conference at Falmouth University, examining craft values in 21st century production. As historic practice increasingly interacts with new methods and materials, new forms of making are emerging. Indeed the very term maker has become a signifier of the blurring boundaries between disciplines, materials and technologies. As we move into what has been called the post-digital age, as objects increasingly become extractions from the virtual into the physical, knowledge of material production, digital know-how and the distinctions between disciplines are developing increasingly permeable boundaries.

References:


Philip Robbins holds an MA from the Royal College of Art in London, a BA from The Emily Carr University of Art and Design and a B.ed from the University of British Columbia. As a founding partner in Polyglot Design, Philip’s practice explores a wide spectrum of materials, media and technology in a career that spans props production for film and television, public artwork and education. Since 2000, Philip has taught across a wide range of disciplines within Visual Arts & Material Practice, Design & Dynamic Media and Continuing Studies, with an emphasis on material practice, 3D software and digital output technologies. As a co-conspirator within Material Matters, Philip has the great pleasure of partnering in a range of cross disciplinary research objectives, exploring that creatively productive space where ideas, materials and process overlap.

Keith Doyle is an Adjunct Research Associate in Applied Arts at Emily Carr University of Art & Design. He has taught in both the Visual Arts & Material Practice as well as the Design & Dynamic Media faculties. Currently, Keith is a faculty coordinator for AD-NODE a GRAND NCE affiliated research project situated in Art and Design institutions. He is a Lead/co-lead investigator on a few Emily Carr research initiatives including, the DnA project, cloTHING(s) as conversation, and a founding faculty member of Material Matters, a pragmatic material research cluster within the Intersections Digital Studios at Emily Carr University of Art & Design. Keith is a co-founder of Intelligent Forms Design Incorporated as well as one of five co-creators of ContainR, a public work of design, consisting of two repurposed used shipping containers. ContainR featured 48 films from around the world, including five commissioned films made specifically for ContainR and broadcast on Bravo!FACT / CTV. www.containr.com. Keith holds both a BFA and an MFA in Sculpture. He is a recent Resident Artist at the ACME Studios International Artists Residency Programme situated in London, UK, a Banff New Media Institute alum, 2006-2007, as well as a NYC Dance Theater Workshop Artist’s Research Medialab fellow. IcarusCar, a five channel video and sculpture installation co-developed while in residence at the Banff New Media Institute has been exhibited internationally and western Canada wide.

Hélène Day Fraser holds a MAA in Design from Emily Carr University and a BAA in Fashion Design from Ryerson University, Toronto. Her fashion-based work in both Canada and France has moved in recent years to encompass critical design: exploring sustainable consumption and textile form interfaces with technology. Between 2006 and 2011 Hélène was a cofounder of the Vancouver based Intelligent Forms Design Inc. (iF) and a member of the UBC based Visual Voice research team that developed Digital Ventriloquized Actors (DIVAs). Currently, she is a Lead investigator on several Emily Carr University research projects: DnA, cloTHING(S) as conversation. She is also Lead Investigator in the international Local Wisdom research network, a member of the ECU Material Matters group and the Operations manager for the Emily Carr DESIS Lab. Hélène’s work consistently re-imagines textile product possibilities and explores art/design-based collaborations.
A Craft Technologist’s Approach Towards Printed Electronics

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Craft Technologists and Paper Circuitry:
A Balancing Act

‘Craft’ is a term that has always evaded rigid definition. In a poll by the Victoria & Albert Museum, London, titled ‘What is Craft?’, Rosy Greenlees, Crafts Council Director, writes:

Contemporary craft... is an intellectual and physical activity where the maker explores the infinite possibilities of materials and processes to produce unique objects. (V&A, 2011)

David Revere McFadden, Chief curator of the Museum of Arts & Design, New York, addresses the unhelpfulness of attempting to wrap craft practice into a tidy definition:

Craft, art, and design are words heavily laden with cultural baggage...they all connote the profound engagement with materials and process that is central to creativity... It is time to move beyond the limitations of terminologies that fragment and separate our appreciation of creative actions, and consider the ‘behaviors of making’ that practitioners share. (ibid)

Finally, Christopher Frayling, Rector of the Royal College of Art weighs in:

Although there’s a strong element of tacit knowledge... in all craft activity, this is in fact far from a secret form of knowledge, just a very difficult one to pin down. Making close contact with materials, technical skills plus imagination, tangible results in the form of things, sometimes pushing at the outer limits of function, taking the material for a walk. (ibid)

These three definitions are disparate enough to demonstrate that craft is inherently subjective; is it exactly what the practitioner makes it. The areas they overlap are clear; the words ‘making’, ‘process’, ‘tangible’, ‘materials’ and ‘form’ repeat tellingly and will be from where I draw my definition. Furthermore, I will be moving from defining craft (or, perhaps more accurately, illuminating craft’s agreed-upon characteristics) to attempt the same for the term craft technologist.

What are Printed Electronics?
It is useful to work with a more concrete definition of

Abstract
This paper opens a conversation around what printed electronics are and how a craft technologist would use craft process values, such as reflection, and an understanding of materiality while navigating this emerging technology. The outcome of exploring printed electronics through a craft technologist’s lens is paper circuitry: an affordable and accessible take on printed electronics that is informed by craft process. Justin Marshall explores the role of technology as a craft tool in Craft and Technology from a Pragmatic Perspective (Marshall, 2002). While Marshall discusses how technology influences craft, this paper will invert the ratio. How can craft processes help to develop printed electronics technology, and by extension, other emerging technologies?

Keywords: Craft, technology, reflection, design, experimentation.
What is a Craft Technologist?
I have only recently discovered (through a passing comment that started with the startling words, ‘I know what you are!’) that I am a craft technologist. Upon hearing this revelation, and agreeing, I was relieved. As a PhD student studying paper electronics, I work with emerging technologies daily. I do not, however, consider myself a technologist. My experience with coding and electrical structures does not make me a programmer or an engineer. I am no artist. I design, but also play, reflect and make; I have a deep respect for material and the history of my medium. And so, when I was told I was a craft technologist, the term resonated strongly.

I define a craft technologist as loosely as the previous definitions of craft: someone who navigates technology armed with craft processes that focus on reflection, play, making and understanding materiality. Its a simple definition, and purposefully vague. It leaves space for the interpretation of the individual practitioner, a crucial freedom in any field that depends fundamentally on creativity.

A craft technologist has a deep understanding and respect for technology, just as a craft practitioner has a deep understanding and respect for materials. A craft technologist’s material is technology. They have an understanding of its history and can work with its limitations. A deep understanding means the practitioner is exploring not just the materiality of a technology, but also the history, social and economic value, different perspectives and context. Through this extensive exploration, a craft technologist gains an empathic understanding of the digital as a material. The craft technologist’s process allows for the finding of new applications and affordances through questioning materiality and limitations. A craft technologist learns by doing, making mistakes and being reflective. Crucially, they explore a material with their hands. By using their hands they gain an intimate understanding of how technologies and materials work.

A craft technologist navigates and investigates the materiality of technology through traditional craft methods and processes of play and reflection. They do not begin with a design problem to be solved, but instead start with a question. The question will be more about experience than function as they are crafting experiences rather than functions. This lies at the heart of a craft technologist’s process of reflect – play/craft – reflect. This process is the author’s own and is used to compartmentalise each stage of a craft technologist’s methodology.

How to be a Craft Technologist
This section is broken into two parts: general skills of a craft technologist and specific skills for a craft technologist working with printed electronics. The first section, covering general skills, will explore the approach and process taken by a craft technologist. The second section will cover specific skills and the toolkit required by them for tackling printed electronics.

General Skills: Process
A craft technologist follows a process of reflect – play/craft – reflect. The process is broken down into these three sections to help with compartmentalisation and documentation.

Stage One: Reflect (inwards)
A craft technologist begins their process by reflecting on the world in order to gain information and insights around their area of exploration. This allows the practitioner to guide and direct their practice. Reflection, as Donald Schön comments (2003), is essential in gaining a deeper understanding into one’s practice. Reid regards reflection as an active and continual process stating, ‘Reflection is a process of reviewing an experience of practice in order to describe, analyse, evaluate and so inform learning about practice’ (1993, p.305). Here Reid is describing a continuous process of experiencing, reflecting and acting, something that mirrors the craft technologist’s process. Reid and Schön agree that reflection provides a better understanding of your practice. Marilyn Wood Daudelin narrows the focus to reflection’s role in relation to learning, stating:

Printed electronics, sometimes referred to as ‘organic electronics’, are created using semi-conducting organic materials rather than inorganic semiconductors, such as silicon. This allows circuits to be printed onto almost anything. Here, that *anything* will be paper – a fantastic and familiar craft material. This discussion of a craft technologist’s approach to creating printed electronics on paper will focus on two elements necessary to all craft processes: reflection and materiality. Printed electronics on paper will, from this point on, be referred to as paper circuitry.

Paper circuitry is the printing of conductive paints onto paper using traditional techniques, transforming paper into low-cost, electronic devices. Basic components can be printed with paint, and capacitive touch achieved easily. Circuits can be screen-printed (Image 1) or even hand painted onto paper. By using these traditional low-tech methods, a new aesthetic can be given to circuitry while maintaining the familiar and revered qualities of paper.

A craft technologist navigates and investigates the materiality of technology through traditional craft methods and processes of play and reflection. They do not begin with a design problem to be solved, but instead start with a question. The question will be more about experience than function as they are crafting experiences rather than functions. This lies at the heart of a craft technologist’s process of reflect – play/craft – reflect. This process is the author’s own and is used to compartmentalise each stage of a craft technologist’s methodology.

How to be a Craft Technologist
This section is broken into two parts: general skills of a craft technologist and specific skills for a craft technologist working with printed electronics. The first section, covering general skills, will explore the approach and process taken by a craft technologist. The second section will cover specific skills and the toolkit required by them for tackling printed electronics.

General Skills: Process
A craft technologist follows a process of reflect – play/craft – reflect. The process is broken down into these three sections to help with compartmentalisation and documentation.

Stage One: Reflect (inwards)
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Reflection is the process of stepping back from an experience to ponder, carefully and persistently, its meaning to the self through the development of inferences; learning is the creation of meaning from past or current events that serves as a guide for future behaviour (1996).

Daudelin proposes that reflection can be used as a tool to attempt to understand the future of a situation. A craft technologist, for example, could use these reflective tools and principals to push a technology further. Reflection, as a concept, is a useful method to practice over every stage of the craft technologist’s process of reflect – play/craft – reflect.

**Stage Two: Play/Craft**

The next stage of the craft technologist’s process, play/craft, will help the practitioner reach better and more creative situations through a much more hands-on and interactive experience than the initial reflect stage. By playing with a technology, it is possible to explore new, unthought-of, creative and unexpected uses (Brown, 2008). By playing, the craft technologist is learning with their hands. They are connecting with the technology and material and gaining a tacit knowledge of its limitations and possibilities through a process of trial and error, and, of course, learning from past mistakes (Image 2).

When playing, a craft technologist continues to meld the practice of craft and technology. This process leads the craft technologist away from simplistic solutions such as embedding a technology in a crafted object or vice versa. They practice craft and technology in a holistic manner to produce artefacts. The result of this learning-through-making is frequently prototypes.

Prototypes are the means by which designers organically and evolutionarily learn, discover, generate and review designs... Prototypes stimulate reflections, and designers use them to frame, refine and discover possibilities in a design space (Lim et al., 2008)

Prototypes then, are extremely useful to a craft technologist, not as a final design solution, but as part of their creative process; their creation naturally calls for the asking and answering of questions and the thorough exploration of a technology. It is through this process that intriguing and magical prototypes are created, giving engaging and inquisitive experiences.

**Stage Three: Reflect (outwards)**

Upon completion of the play/craft stage, the craft technologist moves back into a reflective stage. This time, instead of reflecting inward, they reflect outward. Previously, the craft technologist was reflecting on the world, seeking insights and questioning the area of exploration. Now the craft technologist presents their own work, reflecting on the finished artefacts as well as reactions towards it. Donald Schön suggests that by externalising our ideas we allow ‘the world to speak back to us’ (1990).

This is undertaken either on a personal level, having one-to-one discussions about the work or in a more public manner, either by presenting work in galleries, in talks or online using services such as Instructables, Twitter or Instagram. Outward reflection is a form of dissemination and can be an inspiration for other craft technologists. It also allows practitioners to step back and reflect on their own practice. These platforms allow the world to see what the practitioner is doing and speak back to them through comments (Image 3 details the full process of the craft technologist).

**Specific Skills**

To enable a craft technologist to create compelling prototypes they must possess or learn some basic skills to act as a foundation to their exploration into paper circuitry. These skills can be seen as a launch pad to which the craft technologist can begin to reflect and play with their medium. These basic skills are listed below.

**History and Social Implications**

The craft technologist must have a deep understanding of their chosen area of exploration, in this case printed electronics and paper. Before the practitioner can begin the play/craft stage they must first lay down a foundation of reflections from their field.

For example, to explore printed electronics a craft technologist would conduct interviews with printed electronics companies and explore the history, future concepts, production techniques, development and social implications of this technology. They would also explore paper by considering paper’s materiality, pervasiveness and uses in various industries: music, literature, news, advertising, packaging and art. During this exploration of paper’s history it is important to consider its effects on society and technology. Interviewing experts on paper, and visiting traditional paper factories can help in the generation of reflections.
Printing
Screen-printing with conductive ink is a very fast and low-cost method for producing paper circuitry. To achieve the best results, it is recommended that a screen with a mesh count of 90t be used. This screen has a slightly wider mesh than that of screens used for printing on paper and is normally used for printing on textiles. This large mesh allows for the conductive carbon particles to flow through the screen with greater ease. The best conductive ink to use is Bare Conductive®; when screen-printing it is best to dilute this ink using the ratio one part water to nine parts ink. This makes the ink less viscous and slows down its drying time, thus rendering it easier to work with.

Electronics
One of the easiest ways to craft the interactions of paper circuitry is to connect the paper circuit to the open source platform Arduino (Image 4). An Arduino is a programmable microcontroller that, when connected to paper circuitry, can be used to control outputs such as LEDs, motors and sound. The Arduino is a standard rigid circuit board and, although when stuck to a piece of paper it can take away from the papery feel of the prototype, it is the best way of prototyping interactions to test user experiences.

Connection
Connecting paper circuitry to hardware (such as an Arduino) can be a temperamental task. There are two methods that should be a permanent fixture in the toolbox of a craft technologist when exploring paper circuitry: the paper clip (Image 5) and the bulldog clip (Images 4 and 6). There are details of how to make these connectors in the author’s paper ‘Practical Notes on Paper Circuits’ (Shorter, et al., 2014).

These two connectors allow for the connection of both single and multiple pole connections. The visual language of these two connectors (a cable coming out of what is a very traditional paper tool) adds to the magic and intrigue of the paper circuit user experience. The craft technologist also requires tools to connect traditional components directly onto paper. The best way to approach this is by using conductive epoxy, conductive tape or cold soldering with the conductive ink itself. There is a host of pros and cons associated with these methods, again detailed in ‘Practical Notes on Paper Circuits’ (Shorter, et al., 2014).

Paints and Inks
There are two types of conductive ink that are essential for creating paper circuits: high resistance ink and low resistance ink. The low resistance ink is ideal for creating normal circuits, whereas the high resistance ink is good for creating capacitive touch applications.

Conclusion
Craft technologists aim to bring the best of the known to the new. In bringing craft processes to paper circuitry, the beloved affordances of paper are explored and adapted to inform and bolster this emergent technology; a development I predict will help paper survive the digital age. The qualities of a craft technologist are as follows:

1. A craft technologist uses the process of reflect – play/craft – reflect.
2. A craft technologist learns with their hands and by playing; this leads to a tacit knowledge of their material.
3. By going deep into their subject matter a craft technologist learns about the history, social context, materiality and economic value of a technology. This can lead to an empathetic understanding of the technology and the ability to consider its future in a thoughtful and respectful way.
4. A craft technologist understands craft as a verb as well as a noun.
5. A craft technologist uses prototypes to externalise their ideas, disseminate and reflect on their practice.
6. A craft technologist aspires to crafting magical and intriguing objects through experimentation with materials and technology.

In relation to paper circuitry, the craft technologist’s skill toolset is as follows:

1. An understanding of past, present and future applications and implications of paper and printed electronics on society.
2. An understanding of traditional printing techniques and a knowledge of how to alter these to create paper circuitry.
3. The ability to produce paper circuit prototypes using programmable hardware such as Arduino.
4. Connection methods to allow paper circuits to be connected to external hardware to aid in the crafting of interactions to enhance user experiences.
5. An understanding of the qualities of different conductive inks and how, when and where to apply them.

The combination the craft technologist’s approach and process with the above toolkit allows for the effective creation of paper circuitry that affords intriguing and magical experiences that uphold sensitivity to both the material and technology.

The craft technologist is a new and emerging type of maker, one that facilitates technology to be approached in a reflective and playful way. This newly-recognised practice will lead to artefacts that are craft-centred, technologically interesting, empathetic and magical. Aside from practicalities concerning technology as a material, it is this magical and empathetic quality that can set a craft technologist’s practice apart.

By crafting technology in a recognisable form (in this case, paper) the craft technologist successfully removes any intimidation users may have felt. This allows users to access technology through a comfortable form as well as facilitate an enquiry into the properties of a traditional and familiar material. Their process will lead to viewing technology in innovative and interesting ways by basing an exploration of technology on the rigour of the craft process.

Technology is forever advancing and it is easy for makers to get carried away and create devices without thinking sufficiently about future implications. A craft technologist must understand past experiences and technologies before they can empathetically design future technologies and experiences. The prototype has never been so fundamental a testing ground for expanding on current knowledge and moving into the unknown. Practitioners need to take control of these rapidly advancing technologies and create objects that steer us away from an Orwellian dystopian future. They need to think beyond function and towards experience, towards how these new technologies will affect society. Craft technologists position themselves so that they fully understand past, social implications of a technology in order to try and fully understand its future implications. They craft a respectful and considered future.

References
Becoming a Culture of Digi-Makers: Curiosity, creative confidence and imagination at technology faires

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Introduction
This paper presents observations gained from a participatory design workshop and points to literature surrounding Digital Fabrication, STEM Education and Curiosity, Imagination and Creative Confidence to respond to the question: How is our creative confidence being challenged as we face and engage in becoming a culture of Digi-Makers?

Commercial Makers such as Raspberry Pi and Shrimping.It use Maker Faires as a physical platform to sell or market their products to educators, students, parents and children. They are engaging people the world over in learning how to make or showcase their skills in making with electronics. There are now 98 Maker Faires and Mini-Maker Faires¹ and 200 FabLabs² hosted across the world, evidence that since 2005 a growing global community of people are emerging who appear fearless of making with digital technology hardware, firmware and software. This culture of making is visibly infiltrating the education system through the physical computing in schools strategy (DoE, 2013). Throughout this paper and informed by the literature, I refer to those actively making as Makers and Digi-Makers.

iTECH 2014: Design your future event
In March 2014, and coinciding with National Science and Engineering Week³, the STEMNetwork team organised an event, the first of its kind, in the North West of England called iTECH 2014: Design Your Future. They were tasked with designing a one day event that would be highly interactive, fast paced and excite and inspire up to 200, 11–14 year olds from Greater Manchester schools to enter into careers in science, technology, engineering and maths and meet the people who have chosen careers in making, creating, designing and building with technology.⁴

STEMNet invited The Curiosity Bureau and Shrimping.It to design and deliver a highly engaging workshop. Working together, we could explore the culture of a technology-led event through experimenting with methods of participatory design. This process of collaboration has revealed how valuable participatory design is to nurturing curiosity, imagination and creative confidence in 11–14 year olds. This paper contributes some critical reflections and invites STEM educators and programme managers of informal learning environments to join in a deeper conversation regarding how the design and curation of technology-led events are influencing a culture of digi-makers.

Abstract
This paper reflects on a workshop called ‘The Invention of Things’ where two activities, an Imagination Studio facilitated by The Curiosity Bureau¹ and an Electronics Lab facilitated by Shrimping.It¹, designed and delivered a collaborative inquiry at iTECH 2014: Design Your Future event. Hosted by Manchester’s Museum of Science and Industry and organized by the STEMNetwork Manchester team, the event welcomed 170, 11–14 year old students from across Greater Manchester. In this paper, we present a literature and observational review of students engaged in a technology-led event and participatory design experience. We reflect on the presence and value of curiosity, imagination and creative confidence at a technology-led event when students are tasked with inventing an electronic device through model making with recycled materials and making a working example of an electronic device.

Keywords: Digi-makers, creative confidence, participatory design.
The Maker Movement: Democratizing technology & (digi-)maker culture
Anderson’s declaration of ‘The Maker Movement’ (2012) is now not an unfamiliar term, and Gershenfeld’s introduction of FabLabs from MIT in 2005 said:

Instead of bringing information technology (IT) to the masses, fab labs show that it’s possible to bring the tools for IT development, in order to develop produce local technological solutions to local problems. (Gershenfeld, 2005 p.13)

They found that people were starting to use technology in ways that served a purpose for themselves and their local community. Gershenfeld presents examples from Ghana, Boston, India and Norway (Gershenfeld, 2005), and shows how this phenomenon is fast becoming more accessible to people via FabLabs, Maker Faires and Maker Spaces.

Alongside these examples of FabLabs and maker spaces, is discourse surrounding democratizing technology (Blikstein, 2013; Anderson, 2012). Technology and the digital are accessible now more than ever. Data is opening up, and people are willing to share knowledge and the freedom to co-create, contribute and build onto ideas and inventions. It is creating a culture that is challenging the existing models of intellectual property and commercial capital by using digital as their material or medium. People are now ‘making in public’ (Anderson, 2012, p.13) – this is democratizing technology.

Surrounding this movement of makers, Fuad-Luke asks, ‘can designing and making help us to re-craft capitalism while simultaneously regenerating our societies?’ (2011, p.15). He invites an open conversation based on the potential of designing and making to contribute to developing positive social capital.

In April 2007, American President, Barack Obama, called for the National Academies of Science in the USA to create new and creative ways to engage young people in science and engineering ‘…to be makers of things, not just consumers of things’ (Honey & Kanter, 2013, p.1).

In response to this The Maker Education Initiative; a nonprofit launched in Spring 2012, stated its mission as:

‘[T]o create more opportunities for young people to make, and, by making, build confidence, foster creativity, and spark interest in science, technology, engineering, math, the arts, and learning as a whole. (Honey & Kanter, 2013 p.9)

Whilst literature surrounding the pedagogical benefits of The Maker Movement are a relatively new concept for designing formal and informal learning environments, in the UK physical computing has now become a fundamental part of the curriculum (DoE, 2013), and the responsibility of events such as the STEMNetwork’s iTECH 2014: Design Your Future, are examples of these technology-led forums for teachers, parents and young people to engage in making.

Digital Fabrication in Education
The FabLabs in Schools programme created in 2009 (http://fablabatschool.org) is a global initiative led by Professor Paulo Blikstein at Stanford University. Blikstein promotes the concept of digital fabrication and ‘making’ as the ‘ultimate construction toolkit’ (Blikstein 2013, p.18). He does, however, wish to remind educators and scholars:

[A]s Seymour Papert would say, the real power of any technology is not in the technique itself or in the allure it generates, but in the new ways of personal expression it enables, the new forms of human interaction it facilitates, and the powerful ideas it makes accessible to children. (ibid)

The iTECH event is an example of an ‘informal learning environment’ (Hofstein & Rosenfeld, 1996, pp.88-89), created in response to STEM teachers and STEM Club Leaders who ‘value opportunities to take a more creative and informal approach to teaching their STEM subject’ (STEM Interactive Story, 2014).

STEM activity is encouraged to promote a ‘deep engagement with content, experimentation, exploration, problem-solving, collaboration, and learning. [and these] are the very ingredients that make for inspired and passionate STEM learners’ (Honey & Kanter, 2013, p.4). However, Honey & Kanter also suggest that whilst:

[W]e can create a workshop or makerspace, and we can acquire tools and materials…we will not have succeeded at creating innovative thinkers and doers unless we are able to foster a maker mindset. (ibid, p.9)

The Value of Curiosity & Imagination
Literature surrounding the maker movement and its presence in informal and formal learning environments suggest:

There are strong analogies between the learning of science and children’s natural inclinations to play, invent and explore. Both are motivated by curiosity, investigation and discovery and at the core of both is creativity. (Honey & Kanter, 2013)

In The Aesthetics of Imagination in Design, Nygaard Folkmann (2013, p.67) says:

Through the formative structure of imagination we can apprehend an image that eventually can be transposed to the creation of an object… A genuinely human capability that has always been – and contributes to be – a driving force behind the making of the modern world. (p.67)
Folkmann cites Dewey (2005) and his view on imagination as:

[A] way of seeing and feeling… it is the large and generous blending of interests at the point where the mind comes in contact with the world. When old and familiar things are made new in experience, there is imagination. (Dewey, 2005, p.278).

In contrast, Beveridge warns that when imagination takes place ‘things not seen clearly can take on grotesque forms’ (1957, p.75). This suggests we need not assume, in applying our imagination, we float through a problem-solving space with ease. We, therefore, require curiosity as an enabler to see more clearly the results of our imagination. This suggests that curiosity cannot exist without imagination and vice versa.

An example of an informal learning environment that promotes the value of curiosity in science and art is The Wellcome Collection’, who describe themselves as ‘a free visitor destination for the incurably curious’. They invite visitors to explore ‘the connections between medicine, life and art in the past, present and future’. In his book Curiosity, Leslie (2014) distinguishes between two types of curiosity – ‘diversive curiosity’ and ‘epistemic curiosity’. He suggests that we currently engage with technology and particularly the internet through ‘diversive curiosity’ – a surface level inquiry with a topic or subject of interest. It is only until we dig deeper beneath the surface that we enter into ‘epistemic curiosity’ and experience a far more enriched inquiry.

It is here that he relates epistemic curiosity as being the ‘intellectual steam power of Britain’s industrial revolution’ (ibid, p.107) and proposes that:

[it] is curiosity… that reminds us that the world is an inexhaustibly diverting, inspiring, fascinating place… Curiosity is a life force. (ibid, p.268-270)

Whilst acknowledging how noisy the world is, Leslie also discusses the mental health benefits of being curious. He references a passage by T.H. White, ‘The best thing for being sad… is to learn something’ (ibid, p.270). Dewey regarded curiosity as a fragile quality and suggested that, ‘curiosity can be easily dulled and blunted’ (ibid, p.135).

The Process of Designing & Making, & Building Creative Confidence

Brandt (2007) and Sanders (2010) suggest that it can be through tangible ways of making that the designer can make objects or prototypes to externalize inner thoughts and provide a physical realisation of their imagination. Brandt calls the use of materials and model making in co-design or participatory design as ‘things-to-think-with’ (Lucero, 2011, p.6).

Burr and Andreasen (1989) describe modeling as an important tool for the designer to describe, visualize, and sculpt her thoughts when designing by herself or when designing or communicating with others. (Brandt, 2007, p.179)

Further to this, Cross (2001), known for his concept of ‘designerly ways of knowing, thinking and acting’ believes ‘knowledge also resides in artefacts themselves, in the forms and materials’ (Makela, 2007, pp.158-159) and expresses how knowledge ‘can be gained through making and reflecting upon the making of those artefacts’ (ibid). This suggests that present in the process of making and designing is a degree of knowledge exchange and acquisition, and it is through this iterative process of designing that we require access to our imagination and curiosity – a resource for which we can easily neglect, dull or blunt (Dewey, 2005).

Literature suggests that intellectual curiosity weakens as we grow older (Giambra, Camp, & Grodsky, 1992, p.154), and Honey & Kanter (2013) draw our attention to the observation that whilst children are born with curiosity:

Early in school however, this spark – what psychologists have dubbed intrinsic motivation – is all too frequently extinguished by the extrinsic goals and expectations of school. (2013, p.2)

This would suggest that as students begin to lose the ability to be curious, it affects what Kelley & Kelley call ‘creative confidence’. Kelley & Kelley define creative confidence as, ‘the ability to come up with new ideas and the courage to try them out’ (2013, p.171). Further to this, they pose a poignant question for educators, facilitators, programme managers and curators of formal and informal learning experiences:

If creative confidence is like a muscle that can be strengthened and nurtured through effort and experience, how might we encourage young people to flex these muscles, hone these skills and carry their creative confidence proudly with them in school and in life? (Kelley & Kelley, 2013, p.458)

They refer to the need for ‘a growth mindset’ (Dweck, 2006, p.7). That your true potential is unknown, and, to quote Associate Professor Chris Flink of the D:School on failure,:


Alongside this call for change, are ongoing concerns that the current system of education is not conducive to a growth mindset or welcoming of healthy failure. For example, Honey & Kanter (2013) propose:

We need to develop learning practices that can stimulate students’ passions for science and teaching methodologies that motivate students and support deeper learning. (2013, p.3)
Before entering into the design and delivery of our contribution to the iTECH event we arrived at the following research question: How do we design and deliver a highly engaging workshop for up to 200, 11-14 year olds attending this event and how do we observe curiosity, imagination and creative confidence through making in a fast-paced informal learning environment?

Further to this overarching question, the process posed underlying questions such as:

- Are there tools and techniques available from Participatory Design that could be applicable to designing the workshop?
- How do we engage up to 200, 11-14 year olds in applying their imagination and creative confidence so we can see where it is visible?
- Where is curiosity present in a technology-led event?
- How can the literature and our observations be brought together to contribute a critical response to this growing culture of digi-makers?

We created five research objectives that would aim:

- To respond to the invitation from the STEMNetwork (Manchester), by designing and delivering a highly engaging and fast-paced 15 minute activity for the iTECH event at the Museum of Science and Industry in Manchester (March 2014).
- To explore the prospects of a collaboration between Shrimping.It (an electronics and tech-focused organisation) and The Curiosity Bureau (an experience design and creative facilitation network) by building on the shared interest in people and their curiosity, and by working closely together to learn from each others methods, tools and techniques.
  - To experiment with participatory design tools and techniques in a tech faire environment by being inquisitive of STEM education, 11-14 year old students and responsive to the space and dynamics of the event on the day.
  - To reflect on the curiosity, imagination and creative confidence of participants by facilitating and observing the ways in which they engage with the activities, the materials and the concept of a technology-focused event.

In response to the above, this paper shares observational findings informed by experiencing, via facilitation, a live demonstration and facilitated workshop.

**Research Methods**

Participatory Design (PD) today is an emerging design practice... PD processes usually involve many people having different backgrounds, experiences, interests, and roles with the project. Thus, an important challenge is to find appropriate ways for engaging and involving people in PD activities. (Sanders, 2010, p.195)

The nature of the event encouraged a number of fast-paced demonstrations and workshops. Tasked with only 15 minutes per group of six students, this challenged our approach to facilitating a productive session that would provide time for participants to feel they could engage in a small scale version of The Design:Lab (Binder & Brandt, 2008). An experience where participants are invited to apply their imagination and invent as well as gain a short introductory hands-on experience of the Shrimping.It electronics and its capabilities as a means to realizing their inventions.

We agreed that time was too limited for participants to feel confident of making and designing a unique invention with the electronics available and we made a conscious decision to divide our space into two areas of activity and participation. We decided to call the space ‘The Invention of Things’ and then provide two tables where students could focus their attention on 1.) the process of designing and imagining inventions and 2.) the application of making an existing example (a Persistence of Vision kit) where they could gain a basic understanding of how the Shrimping.It electronics work.

**The Imagination Studio**

Participatory design tools and techniques applied in this activity were a mix of what Sanders refers to as ‘making tangible things’ (2010, p.196) through 3D...
mock-ups and talking, telling and explaining through sharing their ideas with the facilitator and the group. Using cue cards I presented participants with a choice of place, people, input and output (Table 2). They chose one of each, and together they would inform the context for their invention. This method was designed to motivate the participants to apply their imagination and invent with these criteria in mind. I supplied model-making materials (plasticine, spaghetti, glue and recycled materials - card, string, milk-bottle tops, fabric). This invited participants to realize their imagined invention through model making. This low-fidelity approach supported a fast-paced ideation session.

The Electronics Lab
Shrimping.It provided six laptops and breadboards, LEDs and a battery box with a switch to support an activity to code and make a Persistence of Vision device. Cefn (the facilitator) provided instructions and they were also available on a recipe card. At the end of each session Cefn would show an example of the finished device and demonstrate it in front of the students.

Research Methodology
It became clearer throughout the project that a mix of methodologies were important to us. These stemmed from action-research (Marshall, 1999) and design-research (Frayling, 1994; Frankel & Racine, 2010). By being actively engaged in our contribution to the event, we were able to converse, reflect and act upon our decisions as the process unfolded. This became an iterative process that was highly interpretative (Charmaz, 2006). This provoked a fully immersive approach to our research, which we identify with Marshall when she says, ‘I maintain curiosity… about what is happening and what part I am playing in creating and sustaining patterns of action, interaction and non-action’ (Marshall, 1999, p.157). Schön can also be referred to here as he suggests, ‘The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him,

| Place: The Home, Shopping Centres, School/Work, Transport (Manchester City Centre), Parks, Gyms |
| People: Athletes, Gardeners, Police, TV Producers, Farmers, Grandparents, Cleaners, Teachers |
| Input: Light (light dependent resistor, photodiode, camera array), Sound (microphone, microphone), Movement (passive infrared, infrared distance, ultrasonic distance), Triggering (mains, remote controlled devices, networked systems), Magnetism (reed switch, compass), Temperature (humidity, pressure – the weather), Touch (capacitive sensor, touchscreen, button, switch), Acceleration (bit switch, accelerometer) |
| Output: Movement (servo, stepper motion, motor, linear actuator), Printers (receipt printers, LP printers, bespoke systems), Sound (speaker, samples, midi output), Displays (liquid crystal displays, LED matrices, TFT screens), Light (LEDs, single colour, full RGB) |

Table 2
and on the prior understandings, which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation. (Schön, 1983, p.68)

The overarching methodology of this paper can also draw from The Design Science Roadmap (Hevner et al., 2004), as it is through rigor and relevance that a critique has been formed. This paper can be referred to as an outcome with a number of critical reflections that invite further conversation for future iterations of the research.

### Research Outcomes

Throughout the day, 170 students contributed to a wall of ideas and a collection of models (photographed below). They ranged from an X-Factor supporters’ wand that was inspired by the Persistence of Vision Shrimping.It kit (if you move rapidly and programme it to say the name of the person you are supporting and the LED lights paint that name in the air as you move it). Other ideas included a weather sensor for gardeners, a personal trainer personal printer, a sshometer for teachers, to ‘Larry’, a computer assistant for the elderly.

Our reflections after the event resulted in the following observations:

**Observations of ‘The Invention of Things’ Workshop at iTech 2014: Design Your Future**

#### Observations of the Imagination Studio

- Participants appeared fearful or lacking in creative confidence.
- Participants asked; ‘Please can I Google my ideas?’
- The quality of the inventions seemed to demonstrate that participants struggled to think expansively.
- There was little diversity in the inventions as stimulus was required of the facilitator, and when provided by the facilitator would reappear as an idea.
- Little risk was taken by participants to modify or move their idea into speculative imagining.
- The majority of the participants were not animated in their process or excited by their ideas or what their inventions could do if they then decided to use the Shrimping.It technology to realise their ideas.
- Most participants were attracted to the plasticine and used the materials to model their ideas. However, a few struggled with the model-making and preferred to draw, or work with others. Some saying, ‘I don’t know what to do’ and preferred to observe as opposed to participate.

#### Observations of The Electronics Lab

- There was curiosity in the demonstration, which built interest in the activity.
- The instructions were easily followed by participants.
- If mistakes were made participants simply referred to the facilitator or volunteer or the recipe card.
- There were no new inventions created as time was limited.
- Participants responded positively with smiles when they could see the result of their effort when having followed instruction and created an electronic device that worked.
- When it didn’t work they appeared disappointed and some were determined to dwell a while longer to make it work.
- There was little interaction with one another and it was evident it was an activity that required concentration and demanded the attention of the individual.

The diagram below (Image 7) illustrates that whilst both activities began with curiosity (or being curious of the activity itself) and ended with a physical outcome, The Imagination Studio required more social engagement, it required participants to discuss their ideas that were unique to them, as opposed to The Electronics Lab.
which required the focused attention of the individual. With little to no social engagement with one another, the focus remained on the electronic device.

It shows that the journey underwent a curated process of play > creation > outcome = reward + motivation. This also reflected in the work of Fredrickson, who explores motivational triggers in her Broaden-and-Build Theory (2004), and Ryan & Deci and their research into intrinsic motivation and Self-Determination Theory (2000).

A Critical Reflection
Our observations suggest that students were visibly curious of the iTECH 2014 event and of our workshop. Whilst only six computer stations were available in The Electronics Lab, the activity attracted students and teachers. A small audience would build around the activity, suggesting that The Electronics Lab attracted more interest than The Imagination Studio. The Persistence of Vision kit was a good example of how it only takes a short amount of time to experiment making with electronics, and by doing so, arrive at successful making of an electronic device.

Students would arrive at The Imagination Studio and be curious of the activity, but easily distracted by The Electronics Lab, which was being facilitated next to us. Whilst I was animated and enthusiastic in my approach it was a challenge to maintain the attention of the students and interest in an activity where no electronics or technology was present. When asked to apply imagination, I found that some students would simply give-up or sigh, which suggested they were bored, unsure of the purpose of the activity, or lacking in confidence. When they arrived at an idea (the ‘ah-ha’ moment), almost all students did appear to enjoy the activity. It would therefore suggest that it was the journey or process that appeared the least enjoyable task in the activity. When students appeared to hit a brick wall with their thinking, it emerged that participants would seek regular reassurance, permission and a more detailed context for which to design, before they felt confident enough to make models or engage in ideation and invention. This reflects Kelley & Kelley’s concern of students low in ‘creative confidence’ (2013).

I observed that while the iTECH 2014 event provides a highly interactive and engaging maker space, it also presents a contradiction – the need for time and space. These are two key elements conducive to nurturing, building and realizing curiosity, imagination and creative confidence.

Two Key Observations from the Workshop
A Fast Paced Experience, Little Time
• Students were rushing their thinking and therefore not moving beyond the cues of the facilitator.
• Students were easily distracted, jumping from one experience to another, to another – resulting in limited dwell time.

Little Space to Think
• There was little room for epistemic curiosity (Leslie, 2014).
• Limited space to free the imagination and experience healthy failure (Kelley & Kelley, 2013).
• Electronic technology entertained students and filled the physical space between people.

Future Recommendations
We believe our contribution to the iTECH 2014 event explored an interesting collaborative inquiry
surrounding participatory design facilitation, and provided an experimental opportunity that could progress to being applied to a range of technology event formats. Based on time with students being limited, it was a conscious decision to divide ‘Imagination’ and ‘Electronics’ into two separate activities. However, more time would assist in producing an inclusive and holistic learning experience where ‘Imagination’ and ‘Electronics’ could be combined.

Using participatory design tools and techniques in the form of 3D model-making did, as previous research also suggests (Sanders, 2010; Lucero, 2012; Brandt, 2007; Binder & Brandt, 2008; Makela, 2007), prove a successful way for students to access their imagination. This paper invites educators and demonstrators to experiment with The Cue Cards Method (Table 2) and apply it to a variety of learning environments and different age groups.

Upon reflection, curiosity, imagination and creative confidence are perhaps alternative guises for centuries of pedagogical discourse surrounding intellectual curiosity, critical reasoning, creativity, logical and lateral thinking. However, given the democratization of technology, the digital era in which we are now designing learning experiences and the increased interest in making with electronics, there is room for these topics to come together, explored differently and discussed in the context of STEM education.

**Becoming a Culture of Digi-Makers**

At FabLearn Europe (2014), Paulo Blikstein shared his concerns of ‘[three cultures that currently exist in and across the digi-maker landscape]’. Blikstein posits that there is 1.) The Maker Fair – flashy and product over process, 2.) The Museum – fast-rapid experiences and sensory overload and, 3.) Hacker Events – sink or swim, self-directed and competitive. Furthermore, he calls for action across the maker movement to reflect on this, and consider ways in which time and space can be provided to nurture the future maker mindset.

I believe our experience of iTECH 2014 was not dissimilar to Blikstein’s observation of the three cultures. I believe we need to ask ourselves – how much should an informal, learning, technology-led event encourage the consumption of technology? In the design and curation of a technology-led event, are we nurturing a consumer-led or student-led culture of digi-makers?

There is not one easy answer to this question. Therefore, I would like to point to some examples of how the Maker Movement is negotiating this territory of making with student-led culture in mind. Social projects and organisations such as UK initiative Restart (2012), and USA initiative such as Story of Stuff (2007), are examples of communities keen to hack into and mend and make do with the technology that exists amongst them; a different example perhaps of a traditional maker, and one that is not necessarily interested in attending Maker Faires, writing new code or inventing smart objects but keen to build on that which exists.

Fuad-Luke (2011) provides another example of growing human capital and measuring social capital in the context of designing and making a house into a home through an Impact Arts funded project called Fab Pad (2007). This is a youth rehabilitation programme that brings teenagers together to up-cycle materials to make items for their homes. Through making, they are creating not only a sense of identity, but as Fuad-Luke suggests, the results of the project ‘demonstrate its positive social impact… the young people that took part in the project showed increases in their self-esteem and confidence, improved income from employment, better physical and mental health, better debt management, less chaotic lifestyles and new networks of friends’ (2011, p.8).

Could it be that Fuad-Luke’s framework for ‘measuring social capital’ and the focal areas and ‘potential indicators’ for measuring how social capital is developed, could help us in becoming a more considered culture of digi-makers? These focal areas include: prioritising effectiveness of communication; trust between individuals and levels of participation and consensus; exchange of tacit skills and shared understanding of the project context; a sense of challenging values and meanings; improvements in self-esteem of participants and levels of sense of community engagement (Fuad-Luke, 2011). If an informal learning technology-led event were designed with these focal areas in mind, what would the future technology faire look like?

**Curating Informal Learning Environments: The Future of Technology Faires**

A technology-led event such as iTECH 2014 is an opportunity for engagement with making for meaning and for purpose. Puwar & Sharma say that, ‘Curating Sociology favours… cross-disciplinary practices of collaboration and of integration and synthesis of different disciplinary perspectives – those that advance dialogic encounters between different formations of knowledge production and creativity’ (2012, p.46).

It is at the intersection of sociology, technology and design disciplines where a deeper dialogical interaction (Kester, 2004) through Participatory Design (Sanders 2010; Iverson, 2012) meets with the advancing of dialogical encounters found in ‘Curating Sociology’ (Puwar & Sharma, 2012). Therefore, I strongly believe that it is through a deeper investigation and experimentation in informal learning that facilitators, researchers, curators, demonstrators, educators and programme managers could collaborate and co-design a deeper learning experience (Honey & Kanter, 2013). For if we make a conscious effort to design with society in mind, and prioritise skills and knowledge, structure, relationships and experiences (Fuad-Luke, 2011) we could provide people engaged in a technology-led, informal, learning environment with space and time for curiosity, imagination and creative confidence.
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Introduction
This paper describes and discusses a practice based research project, The Glove Project, undertaken since 2011. The focus of which, is two-colour, hand knitted gloves. Initial information and knowledge of this type of glove was found in the early 1980s when I was given a pair in the Duke pattern from Sanquhar, and a visit was made to a collection that contained examples of gloves from the Yorkshire Dales.

Context
I am a maker, being a hand and machine knitter, teacher and independent researcher. The glove project is an independent research project, self-funded and currently conducted alone. It came about following a chance remark from my daughter, also a knitter, about how good it would be to knit many pairs of gloves as shown on the front cover of the book, Selbuvotter (Shea, 2007).

I have knitted plain colour, hand knitted gloves almost all my life, but to move to two-coloured gloves, and to start the project, I decided to knit all of the patterns available for traditional gloves from Sanquhar in Scotland (Scottish Women’s Rural Institutes, 1966, 1979, n.d.). Hand knitting is a curious activity in that it relies heavily on written patterns that have to be purchased, usually at the same time as the yarn for a project. Until the 1960s it seems that the knitting of these gloves originally carried on through an oral tradition, but the Scottish Rural Women’s Institute started to publish instructions for Sanquhar gloves in hard copy, having transcribed them from makers in the area in the 1960s and 1970s. Similar written instructions were documented in the 1990s for the making of gloves in a Yorkshire pattern (Leighton-White, n.d.).

The notion of tradition in this context is slightly problematic as the history of the gloves and their patterns is scarcely known; there being very few examples still in existence. The earliest examples of knitted gloves are those that survive from the middle of the fifteenth century, having belonged to bishops or other clergy. These are usually knitted in silk and gold thread and might originate from Spain or perhaps Italy (Rutt, 1987, pp. 56-58). Single examples occur at various locations in Europe and the UK (Rutt, 1987, pp. 69, 107-108) until it appears that patterned gloves are being knitted in southern Scotland and the Yorkshire Dales, possibly from the late eighteenth century (Hartley & Ingilby, 1951; Thomas, 2014a). Like many
traditions, it seems that it is not as long lived as might have been supposed (Hobsbawm & Ranger, 1983). However, these gloves, knitted in the UK, certainly from the end of the nineteenth century, have a distinct convention for their execution. They are knitted in fine, smooth wool in two colours, often black and white or cream. They have a two-coloured rib cuff, and above that, a band that contains the owner’s initials and the date they were made. Above that is an area of small patterns, often in squares or checks. Sometimes patterns continue up the fingers. The thumb is placed above a thumb gusset for a better fit.

After knitting five pairs of traditional patterns I moved on to my own designs. For me, a knitwear designer and former design teacher, these gloves form an ideal small scale canvas on which to explore ideas. The parameters are strict, although set by myself, in terms of the making, using those set by the traditional glove construction: fine, smooth pure wool yarn; fine needles, construction in the round, meaning that no seaming is necessary; small patterns with a maximum of four stitches in one colour; no more than two colours in one row or even one glove; and initials and, or date, around the wrist. These design constraints make for an interesting design process especially as I work through a variety of different ideas that include personal identity and the nature of family and friendship. I have an active research and design sketchbook.

Making the gloves has been a challenge and an opportunity for learning some new techniques and refining old ones. Quality, in this type of knitting, is often taken as synonymous with evenness of fabric and the smoothness of it. Viewers then question if the gloves are hand or machine knitted. There has to be an understanding of the processes of both hand and machine knitting for a viewer to appreciate that the gloves are indeed hand knitted.

It was an intention from the start of this venture that a blog or wiki would be an integral part of the activity, with the aim of working with another maker and documenting the making process. It was also always intended to document increasing skill levels and also the design process, as was done in the column about training as a furniture designer in Crafts magazine (Bhaskaran, 2009a, 2009b, 2009c, 2009d, 2010a, 2010b, 2010c, 2010d). However, working with another maker has not proved to be possible, and each pair of gloves is made by me rather than in conjunction with another maker. The project has resulted in a body of work being produced that includes sketchbooks, interviews, notes and images from museums and collections, conference papers (Thomas, 2011, 2012) and magazine articles (Thomas, 2014a, 2014c, 2014d).

Historical research has been carried out both through documents and in collections that contain this type of glove. Historical research is important to link the making with that of makers from earlier times, whether they were making silk ecclesiastical gloves in Medieval times or wool gloves in Scotland or Yorkshire in the nineteenth and twentieth centuries. Historic examples have been documented and studied for their construction, materials and patterns in several locations in the UK (Dales Countryside Museum Collection, 2013; Gawthorpe Textiles Collection, 2013; Tolbooth Museum, 2013) with more planned, possibly overseas.

As described above, the research methods have included a range of activities including hand knitting, making both samples and finished pieces, drawing and designing, information gathering, and collection of documentary evidence. These activities link together in a way similar to that described by Sullivan (2010) in which practice and theory are linked in a prismatic structure.

Although the gloves are made by hand, almost every aspect of the work that contextualises them relies on digital technologies. For instance:

- Charting the fabric design is done with a specialist knitwear design software package, Intwined Studio.
- Sourcing patterns is done on line.
- Sourcing materials, including yarns and tools such as fine knitting needles, is done through mainly through specialist suppliers on line.
- Finding further information from other knitters has been made possible through electronic media from email to social media including Ravelry, the knitters wiki (2011).
- The Knittinggloves blog (Thomas, 2014b) enables the recording of The Glove Project’s activities and allows conversations to open up with other makers.
- Collections can be seen and studied on line in those cases where they have been digitised (Future Museum, 2014; The Glove Collection Trust, 2012).

The Glove Project is ongoing. To date, over 20 pairs of hand knit gloves have been made by hand, each taking about 40 hours of work. Themes explored have included concepts of place and the meaning of being Welsh, the Welsh landscape in particular in Carmarthenshire, and ideas of Welsh textile tradition, family and friendship. Gloves are not made for sale but are made for friends and family as gifts. They were selected for the art and design exhibition at the Welsh National Eisteddfod (National Eisteddfod of Wales, 2013) and exhibited with another designer’s work at the Dales Countryside Museum in Hawes, north Yorkshire in April 2014. They were selected for the exhibition that accompanied the ‘All Makers Now?’ conference in July 2014.

Discussion
The project has been designed to allow opportunities to design and make artefacts that are functional and utilitarian. The glove project has been deliberately constructed to allow me, as a designer and design thinker, the opportunity to work through the design process in a systematic and controlled way, with the means of production literally at my fingertips. Having had to have designs executed in factories and by external hand knitting organisations in the past, this is
THEME: DEMOCRATISING TECHNOLOGY

The design philosophy underpinning this project draws its inspiration from makers and design thinkers, primarily Eva Zeisel with her roots in production ceramics (2004), and Anni Albers whose Modernist stance informed her woven textiles (1962 & 1966), although the attitude of these two designers and makers differed radically. David Pye's conceptualisations of workmanship, as those of certainty and risk, are also relevant (1968).

Eva Zeisel, whose design career spanned most of the 20th century (1906 – 2011), reacted against the rigid grids and harsh lines of early 20th century modernism, saying that as a result of it, 'things lost their magic' (2004, p. 15). She argued for the development of a more human approach to the designed object, talking of the ways in which manufactured artefacts surround us and make us feel, and the power that the designer has through their decision making during the design process. She also talks about the way in which objects speak to us, calling this, 'the magic language of design' (2004, p. 14). Through my own design process, I hope to emulate and echo the design philosophy of Zeisel, albeit in a completely different context.

Conversely, Albers was a Modernist and her work was driven by Modernist ideals of rationality. Her weaving being dominated by the grid, the archetypal symbol of Modernism. She too, has values that contribute to this project. She criticises the cult of the named designer saying:

*The design that shouts 'I am the product of Mr X' is a bad design. As consumers, we are not interested in Mr X but in his product, which we want to be our servant and not his personal ambassador ... the good designer is the anonymous designer, so I believe, … (Albers, 1962, p. 6)*

The Glove Project aims to work in the same way as the anonymous makers who have designed and knitted garments and household items over the years.

David Pye conceptualised what he called 'workmanship', that is the process of making an object, as being of two kinds: that of certainty and that of risk (1968, pp. 4 - 8). He argued that certainty was brought into the making process by the use of machinery, while hand processes were always subject to risk. That is the risk that they might not turn out as the maker wants or they might not be uniform. Producing written text with a printing press is an example of the workmanship of certainty but hand writing is an example of the workmanship of risk. I would argue that in my making of gloves, both types of workmanship are present. The production of the smooth, uniform yarn and the fine, uniform needles of recognised sizes, are examples of the workmanship of certainty, and the products of the factory system. While the making of the gloves using the process of hand knitting, exemplifies the workmanship of risk.

In the broader context of the democratising technology theme of the 'All Maker Now?' conference, knitting has been influenced by several factors since the turn of the 21st century. Events such as 9/11 in 2001 in New York, the growth of social media, and the influence of fashion have all played a part in the upsurge in knitting activity since the year 2000.

It has been suggested that knitting is the ultimate comfort activity and it has been argued that the upsurge of it in New York was specifically a response to the 9/11 attacks in 2001. However, Lela Nargi recalls how knitting was ‘certainly in the air’ before 2001 and how she noticed ‘Suddenly knitters were everywhere’ in Brooklyn, New York. (2003, p. 2), at the time of the attacks. It might be argued that this search for a ‘comfortable, homely’ activity was further stimulated by the economic downturn and banking crisis later in the decade, both for real economic reasons of thrift and for the personal satisfaction of taking part in the process of making and creating.

The growth of social media has had a profound effect on the knitting and crocheting community, primarily through the user-driven wiki, Ravelry, although knitters are also active on other social media sites including Twitter, Facebook and Pinterest (Gauntlett, 2011). Self-taught knitters, who use web tools, such as Ravelry and YouTube to learn, teach and refine new techniques and increase skill levels. The use of these tools has enabled some non-designers to establish themselves as significant figures in the knitting landscape with little or no formal design education. In response to the growth of knitting and other crafts, small producers of all types of textile materials have grown up, selling through web tools including eBay, Etsy and PayPal. Makers and consumers have thus been brought closer together.

Using the same media, specialist areas of knitting, such as the patterned glove, can now be made in any location and the results shared, renewing old skills.

In conclusion, The Glove Project allows an exploration of the processes of design and making. It is not known, however, if these processes are similar or the same as those that take place in other types of designing and making. Perhaps comparison with other accounts in the ‘All Makers Now?’ conference might shed light on this question?


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**THEME: DEMOCRATISING TECHNOLOGY**

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Having been involved in making and exhibiting women’s craft work, she was a joint editor of the pioneering Women and Craft (Virago, 1987). Interest in design as a tool for sustainability, led to researching African textile craft production as a means of income generation. This culminated in her PhD thesis ‘The Role of Design in Sustainable Development: A qualitative exploration in the context of the Welsh textile industry’; awarded in 2011. Current research is focused on hand knitting of finely patterned traditional gloves, their design, production, and history.

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Context

3D printing is currently enjoying a frenzy of media attention; digital fabrication, coupled with a global marketplace through the Internet, has been recognised for some years as harbouring the potential for the consumer of tomorrow to ‘design, order, and receive a product without leaving their home’ (Hague et al., 2003, p.27). A decade later, the global 3D printing market reached $2.5 billion, with growth forecast to be worth $16.2 billion by 2018 (Canalys, 2014). In 2014, consumer 3D printing reached the ‘peak of inflated expectations’ on the Gartner Hype Cycle (Gartner, 2014). This was fuelled largely by the expiry in 2009 of the patents on the FDM 3D printing process (Benchoff, 2013). There is now a multitude of affordable machines targeted at consumer use, which raise intriguing questions for the design profession about the future role that consumers will play in the design and manufacture of their objects.

Domestic 3D printers, however, are not necessarily the utopian home fabrication panacea that the media would have us believe. They require considerable technical skills to assemble and operate, and on-going maintenance and adjustment to both hardware and software in order to keep them working effectively. The organic nature of the open source 3D printer movement has meant that the hardware often outgrows the accompanying literature and learning resources that are available, making the assembly process a complex and sometimes frustrating task for the new user. For the patient and technically minded user it can also be a delightful, rewarding, educational, and even profitable activity to build and operate such a machine.

There is growing evidence in literature and practice of users participating in processes of design and innovation without the involvement of a production bureau or a design professional. The Maker Movement has been described as a revolution by a number of authors (Hatch, 2014). The term ‘Makers’ is used to describe the participants, characterized by an increasingly broad demographic of people who participate in creative and design tasks, using digital manufacturing and CAD technologies to make products for themselves. Chris Anderson defined three characteristics of the Maker Movement:

1. People using digital desktop tools to create designs for new products and prototype them (‘digital DIY’).
2. A cultural norm to share those designs and collaborate with others in online communities.

Abstract

This paper documents a project undertaken by undergraduate students of Engineering Product Design at the author’s institution. Five small groups were each provided with a kit of components for a RepRapPro Huxley 3D printer, and tasked with assembling, testing, and then redesigning it to improve or adapt its function. They were asked to document the process, and encouraged to share their learning experiences and innovations online through the ‘Instructables’ website.

The objectives of the project were to emulate the self directed educational nature of the Maker Movement in an academic setting, to foster a level of craftsmanship in students’ use of 3D printing as a tool for design and to explore their attitudes towards open intellectual property.

The results are presented through descriptions of the redesigned printers, observations from the tutor throughout the process, and feedback from the students themselves. Two of the five groups chose to publish their designs online; these were highly positive about the feedback they received from the community. It is concluded that the project provided a highly beneficial, contemporary and relevant project based learning experience, deepening students’ practical understanding of 3D printing technologies and extending the capacity for independent learning.

Keywords: 3D printing, open source, self-regulated learning.
3. The use of common design file standards that allow anyone, if they desire, to send their designs to commercial manufacturing services to be produced in any number, just as easily as they can fabricate them on their desktop. (Anderson, 2012)

The first two of the statements listed above formed the inspiration for the project described in this paper.

Objectives
There is a strong self-directed educational foundation to the Maker Movement, as participants teach themselves to use the technologies to fabricate new objects, learning from, and reciprocally sharing with, the global community via the Internet. This project was established to explore the value of the learning experience that, following a self directed assembly and design project with 3D printers, can offer to students of design, and by extension, to other user groups and makers as well.

The project was conducted with a group of 17, 2nd year students of BSc Engineering Product Design. The philosophy of this degree course lays a heavy emphasis on design through making, particularly in the production of functional prototypes. Students have access to a well-equipped design workshop that hosts a number of industrial-grade 3D printers. Through observation, it became apparent that to the students, these machines represent something of a ‘black box’ in the cybernetic sense (Glanville, 1997), in that they learn to feed files into the software, and to receive the finished model when the print is complete, with little understanding of what happens in between. A technician performs the technical setup of the build; students are taught the principles of how the machines operate through layer-wise addition of material, but have no experience of how they function on an operational level. Thus the second objective of this project was to engender a level of craftsmanship in students’ use of 3D printers, through fostering that intimate understanding of the tools of their trade, which is fundamental to craft practice.

Following Anderson’s, ‘cultural norm to share those designs and collaborate with others in online communities’, the third objective of the project was to explore the attitudes of this generation towards sharing their ideas with the maker community. Students were encouraged to communicate the results of their learning experience, and their own innovations, to the wider 3D Printing community, through the medium of an ‘Instructable’ – an open, online instruction guide for future students or others to follow in building similar machines.

Project Design
In the early planning stages, the option to purchase each printer kit from a different manufacturer was considered. This would have provided an insight into the differences between machines that have all forked and evolved from one original concept. This idea was discounted for practical reasons: after the project, the maintenance and operation of the machines would be considerably easier for the technical support staff with only one model to learn to use. A number of manufacturers were considered, and although cheaper options were available, the RepRap Pro Huxley was eventually selected for a number of reasons: the RepRap brand carries 3D printing heritage, being the first of the commonly available open source machines; the company are UK based, and relatively local to the institution, so it would be beneficial in the longer term to forge a positive relationship with them; and finally, the Huxley model is one of the most compact printers available, making it more suitable for students to move it around and store it.

In order to emulate the self-directed and self-regulated nature of the Maker Movement, it was intended that the students would operate and learn as autonomously as possible (within their individual groups) throughout the project. Self-regulated learning is defined by Vermunt and Rijswijk (1988) as ‘performing educational activities oneself, taking over educational tasks from teachers, educating oneself. Fully self-regulated learning, or fully teacher-regulated learning is, however, less common in higher education than one or another intermediate form’. There is evidence to suggest that the interplay between self-regulation and external (teacher-) regulation of learning can give rise to either congruence or friction between learning and teaching strategies (Vermunt and Verloop, 1999). Congruence occurs if the learning strategies of the students are compatible with the teaching strategies of the tutor; clearly this is beneficial to the student learning experience. Friction occurs when this is not the case, but this is not necessarily detrimental to learning. Constructive friction can encourage students to employ learning and thinking strategies that they have not used before, improving their learning skills. Destructive friction, however, can occur if the teacher over-rides learning strategies that students have employed of their own accord (Vermunt and Verloop, 1998). The intention, in this case, was to stimulate constructive friction by giving the students more autonomy over their learning than they had previously experienced on the course; it was hoped that this would not only increase the depth of their learning and personal development as they encountered and addressed problems themselves, but also that it would highlight the problems that others will face in following a similar project. Teaching was planned to be more reactive than proactive, following a constructivist approach in which the students discovered, and attempted to solve problems for themselves as they arose. In order to avoid destructive friction however, the tutor would be on hand in classes to provide targeted tutorial support when needed.

The budget for the project dictated that the students must be divided into groups. Group allocation is a perennial difficulty in higher education; allocation by the tutor provides a closer simulation of
real-life working environments, but invariably results in complaints from students when individual team members do not make a fair contribution to the work. Allowing students to self-select their groups, however, results in friendship groups sticking together, which can limit the value of the peer learning that might arise from working with unfamiliar group members. This issue was decided through reference to the Maker Movement paradigm, in which like minded individuals tend to self-select groups in which to operate: thus the students were allowed to choose their own groups of three or four members for this project.

Delivery
Each group was provided with a kit of components for a RepRapPro Huxley printer and the necessary tools for its assembly. They were briefed to conduct their own research into the assembly procedure through the official instructions, and any other resources they could find, in order to assemble, calibrate, and test the machine. When this was complete, they were to propose and implement derivative designs that improved or adapted the function of their printers, the inspiration for which was expected to arise from the experiential learning process that they had undergone in assembling it. Students would be formally assessed on their grasp of the technical factors required to build the printer, their clear communication of these through the ‘Instructable’, and innovative thinking in their proposals for derivatives of the original printer model. They were offered a choice of whether or not to publish the ‘Instructable’ online or simply submit the unpublished document to the tutor for their assessment.

Students were timetabled to four hours of lecturer contact per week in a teaching lab, throughout the six weeks of the project. During the first session, an open-ended discussion was held, chaired by the tutor, in which the students were encouraged to share and discuss their knowledge of 3D printing. This highlighted a number of gaps and misconceptions in their understanding of the range and capabilities of the technology. They were also shown a demonstration of another open source self-assembly printer, which had been adapted by colleagues to extrude a syringe full of food paste. They were encouraged to identify key physical and operational elements of the printer, and to speculate on the potential problems they might encounter. During subsequent sessions the students worked in their groups to assemble their printers, with no formal taught content in lecture form. The tutor endeavoured to provide guidance in response to specific questions from the students during these periods.

The printer kits, in boxes, were made available for students to sign out in order work on in the university labs outside of class time. Following impassioned requests, this permission was later extended to allow them to take the machines home or elsewhere to work on them outside of university hours. Four of the five groups took advantage of this immediately, which led to a marked increase in the pace of their assembly work, and the first machine was printing parts by the end of that week, following ‘several all nighters’. In contrast, the fifth group were the only ones not to take advantage of this until the fifth week of the project; these were also the last group to achieve an operational printer.

Project Outcomes: Tutor observations
Due to an administrative issue, the start of the project was delayed by a week until the kits were delivered. This served to build the level of anticipation amongst the students, which was reflected in the tangible atmosphere of excitement when the kits were eventually distributed. One student had to be warned not to rip at the tape in such a way in case he damaged the contents of the box! This level of enthusiasm persisted throughout the classes: without exception, all students were fully engaged by the task, with no requirement for prompting or encouragement from the lecturer. There was generally an excited buzz of conversation throughout, as groups discussed the instructions and their next steps in the build process.

Early issues that became apparent were in identification of the components. Students were encouraged to check their kit contents against the packing list, and several requested help in distinguishing between such components as microswitches, thermistors, and more obscure names such as ‘Rowden tubes’.

Various approaches were used to document their process. One group mounted a ‘GoPro’ helmet camera on the ledge above their workbench and filmed their entire process. Another designated one member as a videographer whilst the others conducted the assembly. The remaining groups used still-shot photographs at key milestones during the process.

One spare kit of parts was kept available for use as spares, which proved invaluable. Despite their checking the packing lists at the start of the project, there were a few small components that were either missing from the pack, or lost or broken by the students. In the worst case, students managed to short-circuit one of the Melzi control boards. This happened during a class workshop, although not under the direct supervision of the tutor. The students were somewhat vague in their explanations of exactly how it had happened but subsequent consultation with the manufacturer suggested that one of them had touched the circuit board whilst the machine was operating, short circuiting something. This served to highlight a flaw in the original design, which that group later addressed in their redesigned model. During the assembly process, students were observed to become more critical of the original components. Spotting the potential for improvement in a marketed product developed their faith in their own abilities to contribute to the design of it.

A number of the groups used the AutoDesk Inventor CAD package to model their assemblies in order to
redesign their machines. This built on skills developed in an introductory CAD module taken during the previous academic year, but despite this, one student observed that ‘when we’re doing it for ourselves, it’s a lot more complex that the classroom exercises that you gave us’.

The first group achieved a functional machine within two weeks of the start of the project, with three of the others following in the next two weeks after that. By week five, one group had already rebuilt their frame, replacing a number of the studded bars with laser cut MDF panels. They claimed that this had an immediate positive effect on the build quality. The same group observed that the machine would still operate when lying on its side at 90 degrees; they were also discovered wearing it on their heads in order to ‘hear the noises it makes through the vibrations’. This suggests an interesting designerly approach to the project, in looking at the issue from, quite literally, a different angle.

The project had been scheduled to run for a six week teaching period. By week five, although all of the printers would be operational, the students had not yet had sufficient time to design and implement their modifications. This was not through lack of engagement with the project, as most were contributing well over the expected self-managed hours. They were therefore offered a choice of two options: to submit on the deadline, but with a reduced submission requirement of just the working machine, the ‘Instructable; and the test components, or to extend the deadline by an further three term time weeks (a total of six weeks due to the Easter holiday period), in which to complete their project to the original deliverables.

Submission requirements for test components were also discussed and negotiated with the students, as they began printing with their machines and understanding their capabilities. The Make 3D printing Guide 2014 used a number of components downloaded from the Thingiverse website in order to test the capabilities of a range of consumer level 3D printers. These were agreed in class as appropriate test pieces that could be compared against each other as a reflection of the quality of the build process and/or the improvements. In addition to this, students were asked to submit a ‘showstopper’ component, that would best demonstrate the capabilities of the machine following their design improvements.

**Project Outcomes: The printers**

The primary design concern of group one was the ‘birds nest’ of electrical cables running around the support structure, which not only reduced the visual appeal of the printer (particularly to the less technically minded user), but also increased the risk of them accidentally becoming caught and disconnected from the control board, which was mounted on the top of the frame structure. They designed and manufactured a control box that would nest between the table and the print bed, housing and protecting the control board inside it. They then protected all of the electrical cables inside expandable sheathes to leave a clean, tidy finish. A colour coding scheme was devised, both to enhance the high-tech aesthetic, and also to improve the ergonomics of the machine by visually indicating the operational components. Black and orange were chosen as the colour scheme, with all metallic parts anodised black, and all remaining plastic parts sanded, primed, and sprayed either black or orange. When questioned on why they did not simply reprint the plastic components using a coloured filament, they indicated that they were unhappy with the layered surface finish that is a result of the FDM process, and wanted parts that appeared as though they had been injection moulded.

Group two increased the Z height build capability of the printer, using extended lengths of the 6mm silver steel and M6 threaded bars that comprise the primary structure of the machine. They were also concerned with the messy aesthetics of the wiring, and so redesigned the frame to be encased entirely in laser cut acrylic, moving away from the triangulated structure of the original. The original design provided no mounting point for the filament spool; when left loose on a table, this could cause problems with the feed. The group extended two of the vertical rods even further above the assembly and hung the filament spool from these on a cross-bar, such that it could rotate freely as required.

Group three observed that the structural stiffness of the frame was affecting the quality of the printed parts. The PLA plastic components of the machine tended to distort slightly under the compression of the M6 nuts, affecting the overall tolerances of the frame. They redesigned the frame to be comprised of two rectangular support plates, laser cut from 8mm MDF. These not only changed the visual aesthetic but stiffened the structure to improve the precision of the build quality. They had also observed that cooling was
an issue, particularly in a machine that built parts in an open chamber that was dependent upon the atmospheric conditions of the room. They mounted two additional large computer fans to significantly increase the airflow over the part as it was built. They named their printer the ‘Huxley FU’, standing for ‘Fanned Up’.

Group four took an interesting approach to the occasionally unreliable nature of the printer. After having experienced several builds that failed, they concluded that the machine should not be left unsupervised, but that it was also inconvenient for a user to have to watch it throughout the build. They designed a mount for a webcam at the base of the build plate. Using a simple piece of freeware, this video feed could be accessed from any web-enabled device, enabling them to leave their machine operating, but to check on it regularly whilst working on other tasks elsewhere. They also added some hinged guards made from clear acrylic, to prevent access to the working parts during the build process. They too addressed the issue of messy wires, although with somewhat less finesse than some of the other teams, by wrapping the bundled cables with red electrical tape.

The final group struggled with the assembly process, and so made less progress than the others. This was possibly due to the fact that of the three members, one withdrew from the course for personal reasons early on in the project; neither of the other two was a native English speaker, and so they found more difficulty than most groups in following the technical terminology in the literature. This was also evidenced by their being more dependent upon guidance from the tutor throughout the process. By the final submission date, their original machine had been assembled and operated successfully, but they had not had time to implement any improvements. The did however submit proposals for these; they wanted to make the machine more attractive to a younger generation of users, following Anderson’s description of giving a 3D printer to his children (Anderson, 2012), by redesigning the plastic components of the machine into zoomorphic shapes, giving it a character, and reducing the technical and machine-like aesthetic.

Project Outcomes: Student feedback
The students were surveyed at a number of points throughout the project, and at the end through a written questionnaire. This consisted of open ended questions in order to discourage prompt specific replies as much as to elicit personal and genuine feedback. The following section presents some of the key feedback points from the students, grouped into common themes, with some discussion of the implications:

Components
- ‘Alignment and accuracy of the print was difficult, but guides and tools were used to fix the issue’.
- ‘Quality of printed parts were bad and often needed sanding / adjusting’.
- ‘The extruder needed to be reprinted’.
Many components for the RepRap printers are themselves 3D printed on the same machines. The students expressed surprise in finding difficulty when assembling these with engineered components such as silver steel rods. This highlighted an important learning point in the tolerances that the machines are capable of achieving, and gave students a benchmark understanding of what their own machines should be aiming to improve on. A number of the groups expressed dissatisfaction with the design of the extruder assembly, although in all cases they did not attempt to redesign this themselves, but sourced improvements through the open online communities.

Resources
- ‘The RepRap Wiki page combined with the knowledge of our lecturer’.
- ‘The rep-rap wiki online; the lecturer’s knowledge; sharing with other groups’.
- ‘Taking the printer home / out of uni. Spare parts already available’.
- ‘The paperwork provided did not provide enough detail as to put together complex parts. Youtube and other videos found to be the most resourceful forums closely behind it’.

All groups used the RepRap instructions extensively, but many also found these to be not detailed enough, or confusing at points, and explored other sources from YouTube and Online forums, and also from other groups within the class. Despite the teaching strategy of reacting rather than leading, several also clearly valued having an experienced lecturer to call on when necessary. The ability to take the kit home, and having a spare kit of replacement parts available was also cited as beneficial.

Assembly
- ‘The breakdown in stages and lack of a comparative model often meant moving back a step to fix something which went wrong earlier’.
- ‘How a 3d printer works, what material is used, importance of accurate building’.
- ‘Fitting parts together, I solved it by a great deal of sanding and hammering’.
- ‘Labelling the wires to keep track of them’.

The sequential nature of the operations in the build process involved a lengthy period of work on the machine before any testing could be done which would show that all of the steps had been followed correctly. In a couple of cases, testing highlighted a mistake that had been made at the early stages of the process. This required another prolonged period of work disassembling the machine to repair the error. This had the positive benefit of encouraging students to develop strategies to assist them in this process, such as labelling the wires for easy identification.

Operation
- ‘How much the environment affects the build quality’.
- ‘Software. [the tutor] helped us’.
- ‘Changing the print settings to find the best’.

Students were surprised to discover the susceptibility of the build quality, in particular the adherence of the part to the bed, and to variations in local environmental conditions. Another hurdle that was problematic for some, was in installing and operating the software, which is a Python based program that proved difficult to install on some of their laptops.

Grouping
- ‘Groups of four may be too much (at best two students at a time can work on the printer)’.
- ‘Too many people in a group. Not much space to move around the machine because of this’.
- ‘If the group is smaller it will take less time to complete the project’.

Several of the students pointed out that no more than two people can feasible participate in the assembly process at any one time, so suggested that smaller groups would enhance the learning experience for all. This of course is constrained by the budget for the project; it also, however, encouraged the students to develop strategies for distributing the workload between them.

Decision Making
- ‘A clear direction is needed for the redesign, this should be decided early’.
- ‘The worst: leaving the redesign build to the last minute. The best: Taking time building the frame to make sure it is calibrated properly’.
- ‘The worst thing was taking a long time to figure out the improvements we were going to make on the printer. The best thing was reverse engineering the printer to make a frame for it’.
- ‘We decided to anodise the metal components for the build – looked aesthetically pleasing but cost us a small fortune’.
- ‘The best decision was to go down the route of designing our own parts. It was a very good experience and some of feedbacks from people which have downloaded our parts is great. The worst decision would be leaving the designing of the parts so late, which left little time for further developing them’.
- ‘Best: Reading through before building; Redesign: CAD assembly on computer followed by MOD1 MDF model. Worst: timekeeping, rushing at the end’.

A recurring theme throughout the comments on decision-making was timekeeping. During the scheduled six weeks, the students contributed well over the expected hours, knowing that they would see the tutor each week and be expected to show
progress. It seems that when the deadline was extended, many of them shelved the project for a while in order to catch up with other work and then found themselves pressured to complete the redesign at the end. The result was that whilst all but one team submitted a redesigned, and operational printer, none of them had left time enough to print out the full set of test components that were intended to be compared for build quality.

Learning experiences

- ‘Hands on! Being able to feel and set up every part was the best part of learning. How the axes work, wiring up, programs’.
- ‘Practical, learning to solve problems as they come about from electrical problems to simple mechanical problems’.
- ‘With this project it was very much a case of learn as you go along, things which we could not predict happening which required on the spot fixes, helped gain a lot of resourcefulness’.
- ‘Having hands on experience of making a 3d printer is something that cannot be taught in a lecture’.
- ‘In terms of improvements to the design you could only really get ideas from your own experiences, which influence the direction you go in’.

The students were generally highly satisfied by the practical and project-based nature of the work, and began to recognise the value of self-directed learning in developing deeper understandings of the work that they were conducting.

Sharing

- ‘Sharing my work and getting a positive response from the online community is an addictive feeling. It has influenced me to build my own printer and keep putting new/improved designs up’.
- ‘I think it is a very useful tool if everyone shares their ideas and tips, it improves everyone’s work’.
- ‘Happy to share it; this is what brings the project forward and this is what helped us create our design. Sharing is caring’.
- ‘Really good: you get feedback and comments which happened a day after it was uploaded showing the community was interested in kit 3D prints’.
- ‘As there are numerous Instructables online we thought it was a bit pointless. But making an Instructable is a good learning curve as we could advise people on problems we encountered during the build’.
- ‘Better not’.

Only two of the five groups decided to share their designs online. These immediately found followers amongst the community; at time of writing, these designs have had 1029 views and 21 favourites, and 840 views and six favourites respectively. These two groups were delighted with the feedback they received from the community. Of the groups who didn’t share the work online, interestingly, most did not provide any explanation as to their reasoning for this. Almost all of them left this question field blank; in total there were only two responses that provided any negative feeling towards openly sharing their ideas. The first of these recognised that the act of creating the instructional material was a useful learning experience in itself; the final one however, was more blunt, in simply stating ‘Better not’.

Discussion

The observations of, and feedback from, students on this project, have served to highlight some key distinctions between theory and practice in a learning experience of this nature. Students of design and engineering are typically taught about the reliability and precision of digital manufacturing processes. This contrasts with the need for careful and continuous maintenance, without which, the parts produced can only be highly variable in their surface finish and tolerances. Optimising the settings of the control software for an accurate build is a process that can only be learned through experience. The theory behind the electronic circuits that control it is far removed from the technical skills of precise soldering and wiring that are needed to make the machine operate effectively. The published instructions carry an authority that suggests completeness; a good build derives from tacit skills in technical assembly that must be developed through practice.

The project aimed to provide as little formal structure to the learning process as possible. This was problematic when balanced against the formal requirements for academic assessment; students did not complete all of the required elements in the printed components for testing. The deadline needed to be extended, although to some extent this was also due to the experimental nature of the project; it was difficult to forecast in advance exactly what rate of progress was realistic to expect. In four out of five cases, the friction caused by giving the students a highly self-regulated learning experience appears to have been constructive in that the students successfully achieved their objectives and expanded their capacity for independent learning. In the fifth case, it is possible that the students’ self-regulatory learning skills were to some extent mismatched with the expectations of the tutor and the requirements of the project, resulting in an incomplete submission.

Of the two groups who published their designs online, both used the Creative Commons Attribution Non-commercial Share Alike licence. The students from these groups were vocal and unanimously positive about the experience of sharing, and the feedback comments from the community were also positive. The groups who chose not to share their designs did not generally attempt to explain their reasons for this. A class discussion had been held in the early stages of the project about the implications of either protecting
or opening intellectual property, but it might be beneficial in future to cover these issues more deeply in classes prior to the project.

Looking forward, it should be considered how this project might best be integrated into the course on an annual basis. It was expensive to run: approximately £2000 between 17 students. This can be offset against adding the operational machines to the departmental 3D printing capability, but the expense makes the project unfeasible to run annually, notwithstanding the fact that the department would soon end up with a surplus of 3D printers that would never be used. One option would be for successive cohorts to begin by learning to operate the previous year’s project submissions, and then dismantling them before rebuilding and redesigning. Another would be to dismantle the machines and repurpose the key components such as stepper motors to other electro-mechanical tasks. A further option might be to offer the students the option to purchase their machines at cost price from the University after the project.

As a learning experience, the students were generally highly positive in their feedback on this project, even those from the group that did not fully complete it. They clearly felt that it was relevant to their careers and enjoyed the self-directed and practice-based nature of it. From a craft perspective, they have deepened their understanding of a tool that will be central to their careers in product design, and the tacit skills required to get the best possible results from the technology.

References


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Designing 21st Century Standard Ware: The cultural heritage of Leach and the potential applications of digital technologies

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Context
As a potter and ceramics practitioner, I investigated how digital production technologies can be used to design and make 21st century Leach Pottery tableware. This included undertaking a visual-historical review of Leach Standard Ware, participating in and observing Leach Pottery workshop practices, and developing practical skills in digital design production technologies like Computer-Aided Manufacturing (CAM) and Computer-Aided Design (CAD) to explore and develop Leach Pottery design and production methods.

The Leach Pottery, established in 1920, is a stronghold of the UK Studio Pottery movement and synonymous with Bernard Leach. His approach to pottery was based in a unique and progressive assimilation of Eastern and Western pottery aesthetics and methods expressed through his practice and writings and further propagated through Leach Standard Ware. For example, Leach, while influenced by traditional pottery from periods like Sung Dynasty China and Korai of Korea (Leach 1946), or early English slipware (Edgeler 2010), frequently combined elements of these periods and regions to make hybrid pots exhibiting combinations of process, materials and decorative styles. Leach can also be seen as a progressive from the perspective of making hand-made high-fired Oriental stoneware that was not synonymous with the largely low-fired indigenous earthenware of English country pottery.

Leach & Technology
In response to some of my negative encounters with potters and enthusiasts, who felt that digital research was incongruous with the Leach Pottery, I sought an understanding of Bernard Leach's position in relation to manufacturing and technology. For this, I focussed on the early key texts of A Potter's Outlook (Leach, 1928) and A Potter's Book (Leach, 1940). Leach presents a complex position in relation to the products of industry:

> After 100 years, the trade offers us crockery which is cheap, standardised, thin, white, hard, and waterproof - good qualities all … the shapes are wretched, the colours sharp and harsh, the decoration banal, and quality absent. (Leach, 1928, p.1)

To Leach, mass-production was inevitable due to the 'widened demands of the increased population' (Leach, 1928, p.1) and the use of machinery was good in some
production contexts (ibid). However, what was important was the way that labour was used: it should not be employed upon mechanical work. Additionally, technology promised the time and resources for a more creative engagement with work:

‘[T]hat labour should be employed eight hours a day, year in year out, upon mechanical work which gives no play to its creative faculties, for that is ROBOT work. With the increase of mass-production shorter hours are bound to come, and with them the time and energy for individual and home production with power supplied by electricity.’ (Leach, 1928, p.1).

More importantly, I took from Leach the idea that the machine is not the enemy of the hand-worker, but an extension of their intentions:

The next step is to get rid of the idea of the machine as an enemy. The machine is an extension of the tool; the tool of the hand; the hand of the brain; and it is only the unfaithful use of machinery which we can attack. (Leach, 1928, p.1).

Just over ten years later, in his seminal A Potter’s Book (1940), Leach maintains his position and praises mechanical manufacture for its efficiency but, again, is critical of its implementation to produce wares that are ‘dull and miserable’ and ‘dead’ in body, form, and decoration:

‘[M]echanical processes are indeed marvellous, as for example the automatic glazing, cleaning, measuring and stamping of many millions per month of bathroom tiles, fired in a single non-stop tunnel kiln, the mere fact of their being mass-produced is no reason why these tiles should be as cheaply designed and as dull and miserable in colour as it is possible for tiles to be; nor in the case of hollow-ware is the casting of shapes so exactly and so quickly and with such perfect pastes an adequate excuse for dead shapes, dead clay, dead lithographed printing or the laboured painting of dead patterns.’ (Leach, 1976a, p.3)

Leach Standard Ware
In defining the cultural heritage of Leach, I foregrounded Standard Ware as one of its most prominent aspects because of the significance of pottery practice to the research and the significance of the ware in relation to the pottery. Standard Ware was the domestic tableware that the pottery began making after 1937 and ceased making after Bernard Leach’s death in 1979. It was the pottery’s first and, so far, most significant period of tableware production and represents the bulk of the pottery’s output for over three decades.

Specific coverage of Standard Ware is sparse. Bernard Leach provides only piecemeal references to it in his writing. Whybrow (2006) offers the first text that provides an overview of many of the potters associated with its production, yet only briefly engages with the ware itself. A richer record of Standard Ware production can be found in a 1952 Leach Pottery film (Gross, 2012), which comes with two narrated versions: one by Warren MacKenzie, and one by Bernard Leach. The film provides a sense of the production and the teamwork that existed alongside a division of labour in tasks like clay preparation, glazing and kiln packing.

While the thesis closely examines several aspects of Standard Ware, this paper focuses on the analysis of Standard Ware forms found in Standard Ware catalogues, which resulted in the development of a visual lineage and the idea of macro and micro standards.

Leach Tableware
In 2008, the Leach Pottery reopened as a museum and educational resource, and resumed the production of domestic pots in a new studio. The new soda fired Leach Tableware, designed by Jack Doherty, heralded the beginning of a second period of tableware production in a body of work which drew a line under the earlier Standard Ware, with distinct aesthetics and a different firing process. Doherty left the Pottery in early 2013, after which tableware design and production moved into a new period of development.

The research focussed on the period of Leach Tableware production.

Leach Standard Ware and Tableware: Macro and micro standards

Lineage of Pots: Macro standards
Using Standard Ware catalogues, I developed lineages illustrating how Leach tableware is described and looks; mapping nearly four decades of Standard Ware production plus the recent Leach Tableware production. All the wares were scaled to the same size to facilitate recognition and comparison. The lineages supported the practice by defining the scope of the Standard Ware and Tableware produced by the Leach Pottery from WWII to 2013, which in turn provides a comparative horizon to help locate the outcomes of the practice within the Leach canon.

The lineages present Standard Ware and Leach Tableware at a macro/design level by illustrating the ‘standard’ of the broader design characteristics (see Image 1). However, even a casual glance at examples of pots from either period suggests a degree of variation between pieces of the same form. Thus, the idea of what that standard is alters depending on the level from which the work is examined. As the lineages are a macro/design level study of tableware, it was also important to examine the pots at a micro/making level to acquire a further insight into standards.

Lidded Soup Bowl: Micro standards
Extending the previous examination of Leach tableware lineages at a macro/design level, the idea of
‘standard’ was examined at a micro/making level as variations between examples of the same Standard Ware and Leach Tableware forms were noted. Such variations question the idea of ‘standard’: an achievement of particular parameters or qualities.

A selection of Standard Ware Lidded Soup Bowls were used as a basis for the sample and interrogated through photography and 3D scans to ascertain their properties. The photographic record (see Image 2), weights and dimensions of the forms, demonstrated variations between the examples of all the bases and lids. John Bedding, a previous maker of the forms, also examined them and identified strong and weak characteristics in their making and aesthetics and discussed their variation in relation to the acquisition of skill and the interpretation of the form through finding personal ways of working.

Overall, the findings showed that the ‘standard’ of Leach Standard Ware can be defined differently depending on the level that is being examined: at a macro/design level the ‘standard’ operates with clear definitions of size and shape. At a micro/making level, comparisons of the same form show deviations from the macro ‘standard’ and it is at this level that the design is interpreted and enlivened by the maker. Standard Ware was a clearly defined body of work that often evolved at a design level, but it also developed through its making: the ‘standard’ was simultaneously fixed and fluid.

**Practice: Methods and outcomes**

Informed by the previously established contextual knowledge of Leach Pottery tableware history, production and artifacts, I then used and explored several CAD/CAM methods, including 3D rotational and 2D flatbed scanners, 3D software, a milling machine and laser cutters. Although digital methods were largely new to my practice, my approach to using these digital tools was grounded in the same spirit as analogue clay practice: to make, reflect and respond.

Digital technologies were approached and implemented in several ways, sometimes resulting in unanticipated enquiries and outcomes. This paper specifically focusses on digital explorations relating to drawing, tool making and designing, and making new 21st century Standard Ware which also involved other potters in its production.

*The Theme of Drawing*

I used CAD as a way of introducing drawing to my
practice in several ways. For example, it provided a method for making 3D drawings of pots, from the Leach Tableware range, which were then used as the basis for designing tools to assist potters in the Leach Studio. Experiments with making CAD drawings and using the laser cutter generated unexpected insights into developing designs for new Standard Ware. Continued experiments with drawing and materials like plaster, led to the creation of laser-etched decorative stamps for thrown ware, and the development of a laser-cut reconfigurable plaster mould (see Image 3).

Tool Making

Working alongside the Leach Studio, I developed and produced a range of tools, such as measures (see Image 4) and shaping ribs (see Image 5), to support the production of Leach Tableware. Using CAD/CAM to design and produce the tools ensured they were an accurate realisation of the pots they were based on. Tool making was taught at the Leach Pottery into the 1970s, where potters often hand made tools, but this skill is not currently taught. CAD/CAM introduces the possibility for reinvigorating tool production at the contemporary Leach Pottery, facilitating more consistent hand-production and standards in the pottery’s studio and even presenting the possibility of remote production.

Designing and Making 21st Century Standard Ware: An echo of Leach

In investigating tool production and developing digital models of Leach Tableware, I then progressed to creatively interrogating Leach Tableware CAD models by slicing and contouring them to re-make the pots in acrylic (see Image 6). The outcomes of contouring, of extracting the digital slices of pots, were used as the starting point for designing new Leach Standard Ware based on the 3D scans and CAD models of Standard Ware and Leach Tableware forms.

The design process evolved through drawing in CAD, by extracting the essence of a form’s line from the CAD models, or 3D scans and using that data in an emergent relationship between the drawings and throwing the designs on the potter’s wheel.

The new Standard Ware range was called Echo of Leach (see Image 7), to reflect the use of earlier Leach forms in its design and in acknowledgement of the involvement of other makers in interpreting the designs and returning their work to the Leach Pottery for exhibition. The designs comprised of diagrams for nine different forms and the work was exhibited in the Leach Pottery’s Cube Gallery (see Image 8) from June-September 2013, reaching an audience of 3000 people.2

Interpretation and Distribution of the Echo of Leach Designs

Six potters submitted their own interpretations of the Echo of Leach brief for exhibition, based on their own clay, process, glaze and firing practices. The aim of including makers external to the Leach Pottery was to extend Standard Ware production beyond the pottery and encourage a wider reinterpretation and engagement with the ware by playing on the idea of the micro/making standard: that the ware comes alive through its making and interpretation.

The Echo of Leach designs were also fully interpreted by the Leach Pottery Studio and explored through my own digital-ceramic practice using laser-etched stamp decoration on thrown ware (see Image 9), and through porcelain slip cast vases produced using the laser-cut reconfigurable plaster mould (see Image 3).

Douglas Fitch, a thrower of traditional earthenware, and Jonathan Keep (see Image 10), a thrower and digital-ceramic practitioner, were both previously unconnected with the pottery and provided interpretations for the exhibition. Personal work was

2. www.facebook.com/EchoOfLeach
also contributed by current Leach Potter, Britta Wengeler, of Germany, and ex-Leach Student Apprentice, Jeff Oestreich (see Image 11), of the USA.

**Findings**

The idea of using digital tools in the context of the Leach Pottery was a difficult prospect for some potters whose perception of digital was associated with a lack of humanity, authenticity and creativity. However, taking Bernard Leach’s ideas about technology as a basis for the research, especially his views that state that: ‘[t]he machine is an extension of the tool; the tool of the hand; the hand of the brain; and it is only the unfaithful use of machinery which we can attack’ (Leach, 1928, p.1), the use of digital technology can be seen as being as valid as any other method if it is engaged with in a thoughtful manner.

Furthermore, Leach’s own approach to practice was progressive and Standard Ware embodies this. Not only in its forms, glazes and methods that borrow and develop European and Oriental pottery themes, but also in the context of its foundations, which were based on David Leach’s industrial training and subsequent part-mechanisation of production processes (Cooper, 2003, pp.206–207). Against this historically progressive context, practice using digital technology is a newly progressive area for the Leach Pottery to explore and one that could enable it to engage with the technological culture of the 21st century.

Overall, the research found digital technology to be useful in the areas of:

- Introducing the potential for quality, standards and enhanced training in tableware production through the development of bespoke tools.
- Facilitating the creative design and development of Standard Ware and exploring the potential for its interpreted and distributed production in a more collaborative format.

For the participants, involvement in the research resulted in some poignant and unexpected reflections. For Leach Pottery stalwart Jeff Oestreich, the practice made him realise that he had not moved far from the Leach aesthetic, which he wished to re-embrace from a less technological perspective on his return to the Leach Pottery:

> In some respects I have fooled myself in thinking my work has grown away from the Leach aesthetic. Your exhibition pointed this out. What I need to do is embrace it all. And being a romantic, when I return in October I will work on a Leach wheel in the museum and not on an electric in the new studio. (Oestreich, 2014)

Jonathan Keep, potter and digital practitioner, succinctly summarises his position on the role of digital within the research and what Echo of Leach offers, which is to acknowledge that tradition is actively made and that it is important for ceramics to be an expression of contemporary times:

> I am a great believer in tradition and feel tradition is an ongoing phenomenon, so in time, digital techniques will just become part of tradition. This was an opportunity to begin to make that move between old and new, to indicate what tradition of
the future might look like. I also believe creative works should be an expression of the time in which they are produced and it worries me how in ceramics there is this terrible holding onto the past with almost a denial of any influence of the present. ‘Echo’ was a chance to learn from the past and through transformations offer a contemporary vision, this is what tradition is all about in my mind. (Keep, 2014)

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Matthew Tyas is a potter/ceramist/maker and recently completed his PhD at Falmouth University. Matthew is keen to publish, more widely, his findings in relation to Leach Standard Ware and its production, both from a historical and critical perspective. He remains committed to making and will return to the pottery workshop, where he aims to explore some of the findings of his doctorate – particularly in the context of tableware design and production. Matthew also works as exhibitions coordinator at the Leach Pottery.
The Digital Craftsman and His Tools

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The Role of the Designer
What is the role of the designer and how is it changing in a time when design and manufacturing become increasingly more digitized? This question is key to understanding the work of Belgium based design studio, Unfold. The studio, founded in 2002 by Claire Warnier and Dries Verbruggen, develops projects that investigate new ways of creating, manufacturing, financing and distributing in a changing context. A context in which we see a merging of aspects of the pre-industrial craft economy with high tech industrial production methods and digital communication networks.

The name Unfold is derived from the first project they developed collaboratively titled ‘a tribute to the surface’, in which a computer program, designed to unfold simple forms, was used on complex 3D models, in this case a 3D scan of their own bodies. Unfolding this digital full-body scan generates a two-dimensional pattern, which after cutting by means of computer controlled processes, is reconstructed into a series of personal jewels in various materials like silver, porcelain and leather. The resulting objects are low polygon copies of the body, giving them a nearly perfectly fitting form, truly made for the wearer. The nature of Unfold’s work.

A Digital Potter’s Studio
When entering one of Z33’s 1 big white galleries, you find yourself standing in front of a long table. There are some syringes, cloths, tools and materials lying on the table, as if the table was used to prepare clay. An apron is hanging in the corner of the room. It feels as if you enter a ceramic workshop, but not an ordinary ceramic workshop. It’s a digital variation of the traditional workplace. On one end of the table is a stool. When you are seated, you face an empty potter’s wheel and an open frame with a green laser line. Behind the wheel the wireframe image of a revolving cylinder is projected on a screen. By crossing the laser beam with your hand, the shape of the revolving cylinder changes according to the movements of the hand. It’s a potter’s wheel where the material to be moulded is not physically present; a virtual potter’s wheel. Visitors of the installation are invited to throw their own digital pots. With the press of a button, they can

Abstract
From knife to hammer to 3D printer, the influence of tools on a design is not to be underestimated. In his essay ‘Tools’, originally published in 2000 in a book covering the work of LettError, a collective of two Dutch typographers, Jan Middendorp (2000) argues for the importance of creating your own tools. He refers to the fact that a craftsman, the predecessor of the designer, was never completely satisfied with the tools that were sold in shops. ‘They always had the tendency to personalize their tools, to appropriate them by honing them, converting them or expanding them. The more specialized the work, the greater the demand for customized or individually made instruments.’ Yet for a long time the instruments of production have been closed systems, discouraging appropriation. This is now changing. Following the personal computer and a range of digital advances, the advent of the personal digital fabricator has lowered the barrier into production and provoked a revival of the idea of ‘making your own things’. Unfold started to ‘customize’ their 3D printer into a clay printer. The open source hardware allows them – similar to traditional craftsmen – to create their own tools. By doing so they break away from a predetermined way of designing, dictated by the existing digital tools. As such, they can thoroughly intervene in the production process, and therefore also in the eventual design. Unfold’s 3D printer for ceramics not only harnesses the potential of new technology and materials, but also projects the past history of specific techniques into the future. The printer has a great resonance with the way traditional potters handle clay, however, because of its ability to produce such fine layers, a new language of forms are made possible. In his book ‘The Craftsman’, Richard Sennett states that ‘In technical craftsmanship, the sense of possibility is grounded in feeling frustrated by a tool’s limits or provoked by its untested possibilities.’ For Unfold, these untested possibilities not only lay in the unlocking of new craft-languages. With manufacturing going digital, we see a merging of aspects of the pre-industrial craft economy with high tech industrial production methods. A combination that has the potential to shift power, from industrial producers and those regulating infrastructure to the individual designer and the consumer. This paper includes excerpts of the article ‘The Electronic Artisan’ by Claire Warnier and Dries Verbruggen, published in 2013 in Disegno Industriale.
save their virtually shaped design in a database. The last 16 designs are projected onto the wall.

On the other end of the table, a machine transforms the digital design into matter. Thin rolls of porcelain clay are layered on a downwards moving platform. The technique is colloquially called 3D-printing. With each new layer, the clay object on the platform grows.

Halfway alongside the table there is a display cabinet, showing the 3D-printed and fired ceramic vases designed by visitors. The installation, L’Artisan Electronique, was developed in 2010 by Unfold, together with interaction designer and creative coder Tim Knapen for the exhibition Design by Performance.

Programming is Much Too Important to Leave to Programmers

Unfold has long been interested into the possibilities of 3D-printing, a technology that connects to their interest in bridging the digital, screen-based world with the physical, material world.

L’Artisan Electronique was the first project that focused on the exploration of the technology, which became possible when, in 2009, they bought a building kit for a Bits-from-Bytes 3D-printer. This was the first building kit for a 3D-printer based on the open source RepRap project. Soon after the development of the RepRap, half commercial building kits came on the market, neatly containing all the necessary elements in one kit and today dozens of commercial derivatives have originated from the open source RepRap. As the machine is self-built and open source, it is accessible and hackable which encourages the user to make adaptations and adjustments. For Unfold this started to awaken their dedication to the crafting of new tools.

In his essay ‘Tools’, (Middendorp, 2000) published in a book covering the work of LettError, a collective of two Dutch typographers, Jan Middendorp argues for the importance of creating your own tools. He refers to the fact that an artisan, the predecessor of the designer, was never completely satisfied with the tools that were sold in shops:

They always had the tendency to personalize their tools, to appropriate them by honing them, converting them or expanding them. The more specialized the work, the greater the demand for customized or individually made instruments.

For the traditional craftsman, the skills needed to create those tools where very similar to the ones needed to apply those tools in the trade. In the digital era the skills to create digital tools (coding), are vastly different from the skills needed to work with those tools. The job of producing digital design tools is thus relegated to big cooperations who produce them, which leads to a myriad of problems. Middendorp states ‘[p]rogramming is much too important to leave to programmers’, (ibid). This is a reference to Giancarlo De Carlo’s ‘[a]rchitecture is too important to leave to the architects’ (De Carlo, Bouman and van Toorn, 2005).

Fascinated by digital tools and inspired by the artisans’ view on tools, Unfold started to customize their 3D-printer into a ceramic printer. The open source hardware allowed them – similar to traditional artisans – to do so. By doing this, they broke away from a predetermined way of designing, dictated by the existing black box digital tools. As such, they can thoroughly intervene in the production process and therefore also in the eventual design language.

The Ceramic 3D-Printer

A RepRap 3D-printer is designed to print thermoplastics. The printing head heats the material up to its melting point and extrudes it through a narrow nozzle, after which, the material cools off and solidifies. Widely used plastics are ABS and PLA. Although these materials are interesting for making prototypes and small parts, Unfold wanted to utilize a more refined material, a material that makes the printed object an end product and not a prototype – clay.

Clay is a natural material that has been used to produce utensils for thousands of years. The fact that ceramic objects are passed on as an inheritance gives them a quality of eternity and value, which is enhanced by their fragility. Next to the more emotional connotation of the material, it also has many specific technical qualities and applications. It is heat resistant and can be heated up to more than a thousand degrees, which makes it suitable for metal or glass casting. It can also be used to insulate electrical wires or for the production of catalysts (water and air filters).

For the ceramic printhead, Unfold based itself on an open source design for a cake frosting machine. It consists of a reservoir for the clay that is connected to an air compressor. The pressure on the reservoir produces a constant flow of clay paste that can be switched by an electronic valve. This way, the shape is formed layer-by-layer, similarly to plastic objects, but without heating the material. After printing, the object is treated similar as other objects formed from clay: bisque fire, glazing and then a second glaze fire.

The extrusion technique that the printer uses is very similar to a technique used in traditional pottery and one of the very first techniques humankind used to create utensils – coiling. The coiling technique consists of building up separate rolls of clay until a solid form is reached. Suddenly this technological application came very close to an age-old craft. Due to this technical similarity, the printing of clay became a logical step in a search for innovation but with respect for traditional crafts methods and their inherent qualities.

All the development and print head designs are shared on a blog under Creative Commons license, with the hope that others improve the designs or find meaningful new applications for them. By open sourcing the development process one can create a large pool of talent to work on it, something which used to be virtually impossible for a small design studio thirty years ago.
Artefacts of a New History
Herbert Read, stated in 1936 that ‘the real problem is not to adapt machine production to the aesthetics of handicraft, but to think out new aesthetic standards for new methods of production’ (McCullough, 1998). While valid, this statement contradicts with what is presented in L’Artisan Électronique where handicraft analogies are translated into their digital counterparts. But the vessels created on the virtual potters wheel should be seen as props in the larger narrative of a museum installation and not as the end goal for the ceramic 3D printing process. Like Read argues, the full potential of a new process can only be discovered through rigorous experimentation and listening to what the tool wants to make. This also resonates with Brancusi’s statement: “You cannot make what you want to make, but what the material permits you to make” (cited in, Pallasmaa, 2009).

Artefacts of a New History was a research project into the intrinsic qualities of the extrusion based ceramic 3D printing process. Early on it was observed that traditional thin walled objects like the vases from L’Artisan Électronique pose a challenge during printing due to the use of soft and slow drying clay and the resulting plasticity of the object while being printed. This often leads to objects collapsing under their own weight during printing. Resembling the idea of the buttresses used in gothic architecture, lighter and stronger structures can be created by integrating a scaffolding into the design of the object itself. Instead of building objects out of thin and unstable walls, they can be printed using complex geometric structures. These types of structures would be very difficult to obtain with traditional ceramic processes, but as Cornell University researcher Hod Lipson states, in his book, Fabricated: The New World of 3D Printing, one of the ten underlying principles fundamental to 3D printing is ‘manufacturing complexity is free.’ As opposed to traditional manufacturing processes, where extra complexity requires a more complicated and expensive mold, there is no penalty with 3D printing when an object is made more complex (Warnier, et al., 2014).

When trying to design these intricate structures for printing in ceramics, Unfold stumbled upon the limitations of the current crop of design tools intended for the 3D printing process.

The G-Code Stacker software, developed together again with Tim Knapen, arose out of this frustration to not have full control on the production process. Middendorp refers in this context to the tool horizon (Middendorp, 2000). It is a typical burden of designers in the digital era: a digital design program is imposed upon designers as if it were a preset straitjacket. Digital programs provide enormous possibilities, but they are never endless. Many designers are not aware that these programs limit their creativity. Once a designer is confronted with the limitations within the program they are working with, they don’t have the possibility to go beyond the borders of the program, not only because these applications are closed source, but also because the skills needed to code them are very different from the traditional designer skills. Because the same tools are used over and over again, the same tool marks are left and the variation in design language becomes sparse.

The G-Code Stacker enables you to design intricate 3D geometries and structures. The software allows you to design much closer to the 3D-printing technique used in RepRap derived 3D printers called FFF (Fused Filament Fabrication). Objects are constructed by extruding lines of plastic (or clay) that trace the outlines of the object filled in with a hatched pattern. This is similar to a 2d plotting machine, but by stacking these 2d layers one gets a 3D object. The standard software that converts your 3D geometry to these toolpaths is called a slicer. The slicer gives you very limited control over the way these paths are drawn.

The G-Code Stacker allows you to control the toolpath and to design an object on a layer-by-layer level close to the process. Mark Ganter of the University of Washington, described the Gcode Stacker in the blog Open3DP:

While it sounds like a crazy idea to engineers (perhaps a step backwards), it makes real sense for cutting edge design (it’s about control). The current crop of G- code generator systems (including commercial code) don’t provide much in the way of graphical G- code editing tools. Further, G-code generators really don’t like objects which are one extrusion band thick. Thus the idea has some real merit. (Ganter, 2012)

Using the combination of the ceramic 3D printing process and the tool path design tool, Unfold was able to develop a new language in ceramics. The results can be seen in projects like The Peddler, a collaboration with the french craft perfumer Barnabé Fillion for which Unfold created a set of objects that resemble alchemical tools and utensils. The three diffusers and different receptacles, both produced using the ceramic 3D print process and the small machine, invite people to be involved in the process, putting a real emphasis on the ritual and the experience of perfume. After dilution the perfume is poured in the central core of the diffuser where it is completely absorbed in the porous ceramic material. These diffusers have intricate shapes inspired by botanical drawings that contain many small compartments around the core, this geometry creates a lot of surface area from which the volatile fragrance molecules can slowly evaporate. A project using virtually the same parameters, but on the other end of the high street/main street (or no street) spectrum, is the ongoing research into the development of open-source water filters for developing countries where the extra surface area could potentially make better performing filters.

Stratigraphic Manufacture
In his book, Abstracting Craft, Malcolm McCullough
tries to peel away the layers of connotations that the term ‘craft’ has accumulated over the years, in order to get to the core of what craft actually is. By abstracting ‘craft’, McCullough aims to find a place for digital tools, techniques and concepts in the realm of craft.

The work of craft is neither the design nor the individual artifact: it is the tradition of the very production. It is the presence of many objects identical in their conception, and interchangeable in their use, but unique in their execution. . . . Craft implies working at a personal scale, acting locally in reaction to anonymous, globalised industrial production. (McCullough, 1998)

By zooming out from the level of the artifact, or the hand of the maker, and placing more attention on the wider context of crafts, McCullough opens up the possibility from using machines and methods reclaimed from industrialism in craft.

In Stratigraphic Manufactury, Unfold explores methods of manufacturing and distributing design in the dawning era of digital production. Stratigraphic Manufactury is a new model for the distribution and digital manufacturing of porcelain, which includes local small manufacturing units that are globally connected. One that embraces local production variations and influences. The installation was commissioned for the inaugural Istanbul Design Biennal by Joseph Grima, curator of the Adhocracy exhibition and former editor in chief of Domus Magazine.

A set of digital 3D files of simple designs was emailed to a network of people around the world who had already acquired the ceramic 3D printing process that Unfold had developed and documented for others to use. The instruction was not to alter anything in the digital design but to be free to incorporate personal and local influences during the actual production process. This freedom ranged from simple aspects like the type of clays used for printing (which influences shrinkage and thus the final size) but also which glaze was used and where and how it was applied, or at what resolution the digital 3D file was converted to tool-paths. These copies were presented in the exhibition as part of a local manufacturing shop. Two Turkish ceramists, Mustafa Canyurt and Ahmet Gülkokan, ran the Istanbul production in the exhibition and printed more localized sets of Stratigraphic Manufactury tableware. Similar setups and collaborations have been presented in New York, London and Taiwan.

Distributed manufacturing is not a new concept. In industry the term can be used to describe a manufacturing system in which the various parts and subsystems of a complex product, like a car, are produced in different locations around the globe and shipped through a supply chain to a single place for final assembly. After this, the final product is shipped around the world again for consumption. The one exception where the term is understood differently is the chemical industry where, due to the cost and risk of shipping chemical substances, manufacturing happens on a small scale as close as possible to the end user (Chrisman, 2010). In the maker context, distributed manufacturing is defined more along the lines of the later example. Small-scale local manufacturing units (think home, small workshops or service centers) are connected to the network which facilitates the exchange of blueprints in digital format. Those digital blueprints drive digital manufacturing tools like CNC routers or 3D-printers. In this scenario, it is the information which is shipped around instead of actual parts.

Often there is the desire to have the exact same output no matter where the part is produced, by using the same materials and machines. For Unfold, the added value lies in allowing the local context and the hand of the maker in the final output. The ceramic 3D print process is still a very hands-on method where skill and experience matter. Clay needs to be meticulously prepared and loaded inside large syringes; material flow needs to be guarded and adjusted during printing. Printed wares need to be finished, glazed and fired. Even when using the exact same machine and material, the output of one maker would be different than the output of another and this should be welcomed.

For a native English reader the title Stratigraphic Manufactury might be oddly spelled. This misspeeling is intentional as if it resembles a word that exists in other languages like Dutch, German or French (but not in English) and which is, like manufactury, derived from the Latin ‘manu facere’ but with a different meaning. The meaning of the Dutch word ‘manufactuur’, is more closely related to the original Latin ‘manu facere’ meaning ‘produced by hand’. The ‘manufactuur’ was in essence a pre-industrial scaled up version of the craft studio or cottage industry with low mechanization and limited division of labour. The advent of the industrial revolution brought a split of the ‘manus’ and ‘facere’, of hand and production and ultimately, of making and manufacturing. McCullough argues that one of the important reasons for this is because ‘the means of production had become too elaborate, too extensive, and too centralized to be owned and operated by an independent craftsman’ (McCullough, 1998).

With manufacturing going digital we can reverse the industrial revolution’s blow against artisans by taking industry and bringing it back to the scale of a studio. Ultimately, it is a merging of aspects of the pre-industrial craft economy with high tech industrial production tools and digital communication networks. A combination that has the potential to shift power, from industrial producers and those regulating infrastructure to the individual designer and the consumer.

The conference title ends with a question mark: ‘All Makers Now?’ Are we all makers now? We’ve probably never stopped being makers, we’ve only stopped being manufacturers. Today, we can all be manufacturers again.


References


Dries Verbruggen is co-founder of Unfold, a design studio based in Antwerp, Belgium. He is currently an associate at the Social Design Master at Design Academy Eindhoven.
Towards the Posthuman: Materiality and process in the creation of stimulus-responsive jewellery objects

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Taking Jayne Wallace’s provision for the amalgamation of technological enchantment and aesthetic beauty as a starting point, my research addresses aesthetic considerations alongside functionality. Thus developing material and technological solutions that constitute an integrated and functional yet unified part of the jewellery object as a whole. While previous projects have placed a strong emphasis on simply creating receptacles to accommodate electronic components within a wearable object, the possibilities offered by digital manufacturing technologies such as rapid-prototyping and computer aided design (CAD), have expanded the aesthetic vocabulary available to the practitioner.

Furthermore, the development and increasing availability of a range of stimulus-reactive smart materials, in addition to the progressive miniaturisation of electromechanical components, has turned the prospect of developing jewellery objects that appear to be responsive to their environment, yet depend closely on an interaction with the physiology of the wearer’s body to stimulate these responses, from a distant imagining into a feasible goal.

Prototyping and Playful Practice
The concept of prototyping, despite being firmly established as an essential part of the concept development – visualisation – prototyping – testing cycle within fields such as product design and architecture and undergoing an increasing amount of critical investigation (Moggridge, 2007), is still not generally recognised as an integral part of the contemporary crafts. Within the context of disciplines such as fashion, ceramics and jewellery design, prototyping is still often referred to as making test-pieces, samples or mock-ups, and thus has received little analytical or critical attention as a process in its own right. In her investigation of design principles used with contemporary craft, Sarah Kettley successfully identifies the internalisation of a particular material or process achieved through visceral immersion through manipulation, handling, repeated exposure and drawing as one of the key factors in imbuing crafted objects with emotionally resonant qualities that transcend mere artistic and personal expression:

“Craft has been described as being ‘without design’ […] It is continuous, rather than discreet in nature, and it is suggested that this is the root of the ‘holistic’ perception of craft.” (Kettley, 2005)

Abstract
The idea of creating a jewellery organism that comes alive on the body has fascinated and inspired my research ever since learning about the potential inherent in smart materials almost ten years ago. While smart materials have been known to scientists for far longer (Huang et al., 2010), and have been used to great effect in engineering and aeronautic applications as actuators, their use in contemporary art and craft has been sporadic, most likely because of the challenges posed in processing and shaping them. With the increased prevalence of digital technologies in our everyday lives, the questions posed to the contemporary craft practitioner regarding the creation of a more refined interaction between the digitally enhanced object and its wearer have become progressively more prominent in the applied arts. Through examining the notion that human biology is a part of material culture, where the body can be shaped, customised or altered through surgical intervention and scientific innovation, my research explores how recent developments in material science and wearable technologies can be viewed as moving towards a future embracing the posthuman body, bridging the gap between craft practitioner and scientific discovery. Developing a holistic approach, whereby material experimentation and digital production processes are used to facilitate the development of aesthetically and biologically integrated wearable technologies, is the goal I strive towards attaining. More immediately however, I am challenging the perception of smart materials and their application within the field of contemporary jewellery in both an artistic and scientific context through proposing the development of symbiotic stimulus-reactive jewellery organisms.
A similar approach to the process of creation is advocated by Soetsu Yanagi, a Japanese philosopher and founder of the Mingei (Folk Art) movement. While Yanagi largely opposes technological development and industrialised mass-manufacturing, he stipulates that the purest form of beauty possible in a crafted object is attained when the craftsman reaches an almost meditative state that is achieved through the complete immersion in his chosen medium. Eradicating the taint of his ego and personal ambition (Yanagi, 1989). Both approaches uphold an appreciation of the value of complete absorption in the process or material of a crafted object without further defining how this process might take place.

Some steps towards analysing and defining such processes of immersion in contemporary craft practice have been taken and are encompassed by the concept of playful practice. As Nina Lieberman states in her examination of playfulness and its relationship to creativity and imagination:

> Among the personality characteristics of his art-wise subjects, Child (1965) found a capacity to escape momentarily from the unusual logical restraints of adulthood and the ability to take an interest in playful, imaginative and unusual aspects of things. […] The model here would suggest that, to the extent that the playful enters imagination and originality, it creates that suspense of tension, that psychological distancing required for the idea to form and to be produced. (Lieberman, 1977)

As soon as playfulness is combined with prototyping a creative process of trial and error emerges that can yield innovative and sometimes unexpected results. This process is a key part of my artistic practice, and one of the main cornerstones of my research methodology.

Using design methods such as drawing, photo studies, collage, material experimentation, and CAD (Martin and Hanington, 2012), my research process consists of developing a series of prototypes as well as finished jewellery pieces and objects. With each of these prototypes my understanding of the material qualities and processes used increases until I am able to develop a personalised, original, visual language that transcends functional considerations and focuses on harmoniously integrating microelectronic components and smart materials into a jewellery object that is both aesthetically as well as functionally resolved. Through engaging in a holistic process of material immersion and experimentation, I am developing a body of work that encourages personal artistic expression while leaving space for serendipitous discovery. As Michael Schrage puts it:

> The real value of a model or simulation may stem less from its ability to test a hypothesis than from its power to generate useful surprise. […] It holds equally true that chance favours the prepared prototype: models and simulations can and should be media to create and capture surprise and serendipity. (Schrage, 2000)

The difficulties of applying such a methodology of playful interaction and experimentation to CAD modelling have been well documented and are the subject of much discussion. Makers without an intimate knowledge of coding languages and algorithmic computation often struggle to create object files that push the boundaries aesthetically whilst still fulfilling the many requirements that constitute feasibility for the three-dimensional printing process. Thus allowing the transition from an idea on the screen to a physical object. As Tavs Jorgensen points out:

> While digital media has the potential to free craft practitioners to create beyond the physical constraints of his/her skills, there are still important elements of traditional craft practice which remain relevant and have yet to find a transition into new media. (Jorgensen, 2005)

Solutions such as the Tacitus Project (Shillito et al., 2001) and the Cloud 9 software package (Shillito, 2014) strive to re-design the virtual workspace and the devices used to interact with it by enabling haptic feedback modelling. But investing in such technology represents a large financial risk for the individual designer-maker, as well as a serious time commitment to learn the software. Similarly, Jorgensen's use of the ShapeHandplus Motion Capture System to create flowing gestural forms (Jorgensen, 2007) is an unfeasible process for most craft practitioners as they lack access to the device.

There are aesthetic risks too when committing to such an approach. The Cloud 9 modelling environment enables its users to treat the virtual material being worked on like clay, pushing and pulling with the haptic Novint Falcon controller and delivering real-time tactile feedback. Through this, the Cloud 9 System emulates the process of interacting with physical materials through experimentation and creative play, despite still functioning within the parameters of a two dimensional virtual workspace.

This might seem like an ideal solution for those makers wishing to use CAD technologies in their making process while maintaining their ability to directly interact with the form they are developing. However, it is all too easy to produce forms that are aesthetically uniform, creating ‘blobtecture’ objects (Masterton, 2007) that are immediately recognisable as having been generated in this way.

In a similar vein, the digital ‘cyberpunk’ aesthetic created by more widely used programmes such as Rhinoceros 3D, AutoCAD and Solidworks has become instantly recognisable. Both of these aesthetic stereotypes can be attributed in part to the inherent difficulty of creating an object that contravenes
geometries and design processes dictated by the computational logic of the individual programme used without delving into the unknown depths of grassroots programming. In his research, silversmith and digital maker, Drummond Masterton, addresses this issue by painstakingly reviewing and manipulating individual lines of code within the CNC milling program he uses. While he admits that ‘[t]he objects do not escape a CAD aesthetic any more than a hammered bowl escapes a hammered aesthetic,’ (Masterton, 2007), Masterton’s contemplative absorption in the minutiae of programming counteracts a tendency inherent in the process of CAD to rapidly work through multiple iterations of a digital design without questioning its aesthetic qualities. In this, Masterton comes close to Yanagi’s ideal of meditative immersion, using the digital just as he would more traditional hand tools to play, reflect and experiment.

However, while these different approaches to create a less conventional methodology of digital creation are suited to the individuals who have engaged in developing them, I found that none of them suited the aesthetic I was striving to create in my own work. Taking inspiration from natural growth patterns such as those found in microscopic structures and fungi, my aim is to develop an approach to digital design that will allow for unpredictable and random manipulation of geometric structures. Most natural forms follow rhythms of growth dictated by underlying mathematical algorithms such as the Fibonacci sequence. It is in this aspect that CAD and nature intersect in a fortunate way, and the field of generative design, populated by mathematicians, architects and programmers turned crafts practitioners bears witness to this fact.

In combination with digital means of production, artists such as Neri Oxman (Oxman, 2010) have created some truly astounding pieces of digital art; beautiful in their regularity and perfection as well as ambitious in scale and material choice. Some CAD software even has the capability to mimic processes of natural growth through providing plugins that automatically generate algorithms according to user-specified parameters. An interesting example where this possibility has been placed in a commercial context is the Nervous System algorithmic model, Rhino, as it is commonly referred to, allows the skilled user to create and manipulate a large variety of objects consisting of surfaces, curves and control points. For the novice, an advantage of Rhino is that it is possible to create complex and mathematically precise objects by joining, copying, pasting and adjusting a series of pre-set three-dimensional solids, or to create new solids from two dimensional curves. Once a solid has been created it can then be exploded into its component parts (surfaces, curves and points), which in turn allows for the direct adjustment of these components by the more experienced user in order to create shapes that diverge from the known matrices before re-joining them.

Finally, the NURBS solids created in this way are translated into stereolithographic (STL) files that describe the surface geometry of the created object in triangular segments in a process known as meshing. The resulting triangulated mesh represents the final output Rhino is capable of producing as the program has only a very limited capacity to work with mesh objects directly.

The first object I created for my body of research using Rhino is the stand for the Clathrus Ring (Image 1). Inspired by the geometric lattice of the Clathrus mushroom, the structure of the stand was constructed by fusing individual surfaces in modified hexagonal patterns. This method of creating an object, while affording a maximum degree of control over the final outcome, is extremely labour intensive and also means that objects cannot be easily manipulated.

Additionally, this approach is much more suited to the creation of geometric surfaces than anything requiring a more organic aesthetic. Rhino’s user...
interface is not particularly intuitive, and often the adjustment or building of individual surfaces from curves creates problems with the underlying mathematical integrity of the geometry of an object. A reliance on extreme precision means that often objects created in a more unconventional fashion that do not follow protocols of methodological sequences established as 'the right way of doing things' within Rhino, can become riddled with bad edges and inverted surfaces, which cause problems during the 3D printing process. Fixing such objects can be a long and drawn-out process often requiring the rebuilding of troublesome areas of a model, and might not be at all possible on occasion.

Consequently, and in line with the idea of a more playful approach to CAD modelling, I have developed a methodology which enables me to build complex geometric structures in Rhino and export them as polygonal meshes instead of NURBS or surface-based objects. These are subsequently imported into a mesh based CAD modelling program where they can be shaped, deformed, joined and manipulated freely. One of the first pieces I created using this technique was a stand for the Mycelia Brooch (Image 2), which echoes the structure of the brooch as well as the irregular bubble texture of its central silicone and mineral elements. Other shape experiments (Image 3) are much more unpredictable in their geometric realisation than similar objects would be using computational modelling, reflecting the direct involvement of the artists' hand in their creation. Taking these shape experiments forward by combining them with smart materials and integrating them into an aesthetically cohesive jewellery object is the next step in my research process.

Towards a New Materiality
Since the first institutional materials library in the UK opened at the Royal College of Art in 1974 (Wilkes, 2011), the increasing desire by designers, visual artists and materials enthusiasts to explore a wide range of both commercially available and highly experimental materials in an open, collaborative environment has given rise to the exponential growth of materials libraries over the last decade. Within the UK alone, nine materials libraries currently operate, each with different foci and access parameters, ranging from those based at academic institutions to fee-paying commercial consultancy ventures. While some libraries select materials by focusing on a particular discipline, such as architecture, interior design or the construction industries, others specialise in rare, laboratory-grade materials. Most commercial materials libraries also have extensive searchable online databases, whilst others exist only online and have no physical site to examine materials first hand.

However, while the agenda of sharing knowledge and creating connections between materials scientists, the materials industry, designers and artists is a worthwhile one that should be encouraged, particularly at a time when collaborations between the arts and sciences are essential for the development of new cross-disciplinary approaches, there are still significant barriers in place when it comes to creating such exchanges. Advocates of materials libraries such as Mark Miodownik of the Institute of Making, London, praise their ability to encourage scientists to think about the senso-aesthetic properties of materials rather than their functionality by consulting artists, designers and crafts practitioners, whose main focus arguably lies in identifying how users connect with materials on a more intuitive level:

Characteristics such as smell and feel are almost impossible to capture in simple numbers, (Miodownik) noted, and many modern products show evidence of the fact that these properties were
Miodownik's plea applies to material scientists and arts practitioners alike – with one group needing to explore ways of designing materials that contain optimum functionality while also taking into account sensato-aesthetic properties. The other group engaging with how such materials could be used sensitively in designing an object with maximum functionality whose tactile and aesthetic qualities capture the imagination of the end user.

The constraints currently faced by materials libraries in achieving such a goal are still significant. While the idea of the materials library as a collection of unusual materials to be made available to arts practitioners, researchers, and scientists alike may have been around for thirty-nine years, the serious progression of a strategic agenda in terms of building such collections and making them available to a larger audience is a fairly recent development and has only really gained momentum since the beginning of the twenty first century. Even those materials libraries that have been established over the last decade, both in academic institutions and as commercial ventures, are limited in the scope of their expertise. As Miodownik points out:

_They serve very specific design communities, their materials collections are extremely limited, they only deal with commercial materials, but most importantly, they are almost completely dissociated from the materials-science community._ (Miodownik, 2009)

Additionally, the ties between industrial suppliers of materials and materials libraries are tentative at best. Many suppliers are reluctant to provide experimental materials in quantities small or large enough to be useful to arts practitioners in their research and development, or indeed at all. In her conversations with material librarians, Sarah Wilkes extrapolates that:

_In the eyes of many involved in materials education, concerns over corporate secrecy and ownership on the part of materials producers are a hindrance to both creativity and technological progress._ (Wilkes, 2011)

The questions of intellectual property and pending patent applications loom large during such exchanges between supplier and practitioner, and frequently a satisfactory conclusion cannot be reached. While some of the most interesting materials represented in materials libraries are often in a pre-commercial stage of development, suppliers are worried about providing such materials to researchers before potential revenue-generating avenues have been exploited. This quickly turns into a catch twenty-two situation, with many materials never reaching financial viability at all due to their lack of practical applications and thus commercial demand. Often such demand might have been created if designers and arts practitioners had been encouraged to experiment with these materials and thus potentially discovered novel and previously unanticipated ways of using them. To recognise the potential of such mutually beneficial relationships, a liaison between industrial suppliers and creative practitioners, experienced in dealing with the concerns of either party would be necessary; something a lot of materials libraries are struggling to provide as of yet.

As part of my research, I have visited three materials libraries so far: the Materia Inspiration Centre in Amsterdam, the Innovathéque FCBA and the Materió Materials Resource Centre, both of which are located in Paris. These field visits have been valuable and enlightening, with materials having come to my attention that might not otherwise have. However, they have also revealed inherent difficulties faced by individual craft practitioners and artists looking to use materials libraries for their practice – in particular accessibility and utility of the information acquired.

While open-access libraries such as the Materia Inspiration Centre, now unfortunately closed permanently, operate on a sponsorship model and rely on contributions from manufacturers to display new materials in their physical and online libraries, most other materials libraries not operating under the umbrella of an academic institution currently operate on an annual or monthly subscription based-model. As can be seen in the case of Materia, the sponsorship model is highly dependent on sustaining support from materials manufacturers and industry clients, who in turn follow the dictates of wider economic circumstances. A recent downturn in the construction industry and its associated branches has meant that demand for the services of Materia, and thus its financial support, has waned (Materia, 2013). The decision was taken to close the physical site in Amsterdam. Materia's collections are still available for viewing through travelling exhibitions at trade shows, and the online database remains fully operational. For the individual practitioner seeking tactile access to materials, this is still a grave loss.

On the other hand, both the Innovathéque FCBA and the Materió Materials Resource Centre operate on a subscription based model. In an interview with Brice Tual, materials consultant at the Innovathéque FCBA, I discovered that one of the main motivations for using this model is to enable a more critical and independent criteria-based selection system for the inclusion of new materials (Vones, 2014).

Tual states that the Innovathéque FCBA selection committee, consisting of up to six members from a variety of backgrounds, meets four times a year to whittle a pre-selection of over 2000 materials down to a maximum of 250 for inclusion in the library per year.
Selection criteria are stringent and immediately exclude any materials without safety data and technical information, effectively shutting the door on materials that are still at a lab-stage of development. While this is entirely understandable for a commercial venture aimed mainly at sectors such as product design, fashion design, architecture, furniture design and ecological design who use these libraries as a time-saving shortcut in their product development cycle, the scope of the materials on offer is immediately curtailed. Furthermore, the library’s role as mediator between designer and supplier ends after the first introductory phone call; all negotiations that follow are to be conducted entirely by the clients themselves.

Additionally, there is no established system of classification for the materials kept in materials libraries, and with each library having devised its own way of displaying, storing and cataloguing their collections it is virtually impossible to tell whether any particular library might be of use to the individual practitioner without extended visits to the physical sites or online databases. The increasingly rapid development of new materials often renders holdings obsolete and the issue of shelf space means that legacy materials are frequently discarded or consigned to inaccessible storage indefinitely.

The relatively expensive annual subscription packages offered by materials libraries, affordable to commercial clients and governmental bodies, are financially overwhelming for individual craft practitioners and self-employed designers. As a result, only very few have access to these resources. Materials libraries based within educational establishments, such as the Institute of Making at Kings’ College London, seek solutions for individual makers to have improved access to their collections by arranging monthly open-days, masterclasses and running a MakeSpace. But these are very recent developments and the classes and facilities are currently only open to staff, students and researchers based at the institution. It seems that for the adventurous craft practitioner without an academic connection it would be more beneficial to engage in the initial research process themselves by visiting materials expositions, conducting internet research and contacting suppliers directly.

Exploring the Future: Smart materials
I initially became aware of a group of smart materials known as Thermochromics through a presentation given by Dr. Sara Robertson (Robertson, 2011), at the CIMTEC 2012 conference in Montecatini Terme, Italy, exploring the potential of temperature-sensitive thermochromic dyes and heat-profiling circuits in textile design. Intrigued by their ability as a smart material to respond directly to a change in body temperature through colour change, I began to explore their potential in combination with the three dimensional silicone shapes I had been developing.

Thermochromics are commonly available as either dye slurry or in powdered pigment form, and fall into the two main categories of leuco or liquid crystal thermochromics. Either variety is available in a range of colours and with different temperature change points that display a visible colour change with an increase or decrease in exposure temperature. Leuco dyes change from pigmented to colourless when a hot or cold source is applied, which depends on their change temperature, and assumes pigmentation again as soon as the source of temperature change is removed. Analogue Liquid Crystal dyes cycle through a set of colours that correspond to the temperature they are exposed to. The most recognisable form being the ‘peacock’ colour pallet ranging from red through yellow, green and deepening shades of blue. After a certain peak temperature is reached towards the dark blue spectrum, usually about 20 degrees above activation temperature, visibility of the pigment ceases. It only returns in the cooling phase when it cycles through the previous colour shifts in reverse until it once more falls below its activation temperature. Digital Liquid Crystal technology, in which the pigment appears to be either in an on or an off state according to the temperature it is exposed to, has also recently become available. The colour change reactions of thermochromic dye systems are available as reversible and irreversible types. However, as one of the definitive conditions of smart materials is full reversibility, only the former type can be categorised as such and is of interest to me in this respect.

There are a variety of practical and industrial applications for thermochromic pigments, dyes and paints. One of the most well known is the inclusion of
liquid crystal technology in forehead thermometers. Each degree of measured body temperature is assigned a corresponding colour. Similarly, Leuco dyes are widely used in fuel assemblies to test combustion engines and as friction markers in engineering, affecting an irreversible colour change when heated and thus signalling a state change of the monitored component (Robertson, 2011).

My research currently focuses on exploring the potential of layering leuco and liquid crystal pigments in silicone to explore the interplay of colours created by different colour and temperature combinations. I have adopted a rigorous testing protocol for these experiments, starting with four base pigments in different colours and each with a different change temperature (Blue 27˚C, Yellow 38˚C, Magenta 41˚C, and Red 47˚C). Each batch of samples is made using the same process, requiring 16.5 g of mixed silicone for a full set of 25 with one extra shape as a spare. An initial set of shapes of each single colour was prepared, starting with 0.1 ml of pigment and adding 0.05 ml of pigment every five shapes (Images 4 & 5).

Next, two pigments were combined in a single mix, starting with 0.1ml of each colour (a total of 0.2 ml) and adding 0.05 ml of each colour (a total of 0.1 ml) every five shapes. The resulting colours were then evaluated for hue, transparency and strength of pigmentation in both their changed and unchanged states. In their unchanged state, pigmentation strength is greatest in the final segment of each colour, with saturation levels nearing opacity, and weakest in the first segment, creating a translucent finish. Translucence yields to opacity at around 0.3 ml of added pigment. This result was predicted and corresponds to expectations formed by my past research in combining artists pigment with silicone.

The resulting colours of the combination samples follow the general rules for colour mixing as demonstrated on a colour wheel, and the resulting hues range from slightly disappointing to very pleasing, although this is arguably a matter of taste and artistic intent. With the application of heat, the samples go through a variety of colour changes. In their first changed state the lower temperature colour fades and reveals the underlying higher temperature pigment. The samples appear as a lighter version of their unchanged colour at this stage, with some combinations such as blue and yellow displaying a very distinctive change, while others such as magenta and yellow displaying a more subtle outcome (Images 6 & 7). If heated again, the second pigment fades and reveals a milky base colour with the dominant pigment in evidence as a pastel shade (Image 8). It is possible to further modify the colour response by introducing a permanent base shade consisting of artist or special effects pigments to the mixture. I am currently conducting tests to exploit the aesthetic possibilities inherent in this suggestion.

Conclusion: Towards a posthuman future?
Through conducting extensive materials research, shape explorations and colour experimentation, I have created jewellery objects containing thermochromic silicone in conjunction with 3-D printed structures that employ both traditional and modern jewellery making techniques such as photo etching and laserwelding. The resulting experimental pieces transform as they are being worn and respond intimately to temperature changes in both the environment and the human body. While the Xylaria Brooch (Image 9) uses leuco dyes to affect a subtle change in colour from orange to deep raspberry pink when reaching an environmental temperature of around 38˚C, the Cocoon Necklace (Image 10) also incorporates 3-D printed shapes coated in liquid crystal pigments that begin their transformation at around 25˚C, evoking the colours of a peacock’s feathers. Collaborations with textile artist and researcher Dr. Sara Robertson (Image 11) to develop a process of creating translucent thermochromic silicone fabrics, and medical engineering researcher Markus Pakleppa (Image 12) to fabricate a temperature reactive scale model of a human colon to aid cancer patients in visualising the internal workings of their bodies, have enriched and guided my research process.

Potential practical applications of my jewellery objects exist in the areas of human–computer interaction, transplant technology, medically assistive objects, identity management and artificial body modification including prosthetics, where such symbiotic jewellery organisms could be used to develop visually engaging yet multifunctional enhancements of the body. Moving towards a future in which technology could become permanently integrated into the complex systems of the posthuman body I am intrigued by the possibilities and challenges facing the contemporary jeweller in advancing the debate surrounding the posthuman and interactive adornment. The intersection between technological refinement, the exploration of smart materials and new manufacturing technologies, as well as the development of an aesthetic expression that
supersedes ideas of mere gadgetry, is a challenge in this area of research and one which I am in the process of addressing with my contribution to the field.

References


Katharina Vones is an award winning jewellery artist and digital craft researcher at the University of Dundee, currently in the final stages of completing an AHRC funded PhD investigating the use of smart materials and microelectronics in the creation of stimulus-responsive jewellery. She completed her BA(Hons) in Design and Applied Arts at the Edinburgh College of Art in 2006, and gained an MA RCA from the Royal College of Art in 2010, after which she established her practice in the Scottish capital of Edinburgh. Katharina has exhibited her work widely both nationally and internationally and actively blogs about her research and material explorations as a way to encourage craft practitioners to learn about and get involved in digital technologies.

www.smart-jewellery.com / www.kvones.com

THEME: MATERIALITY & AESTHETICS
