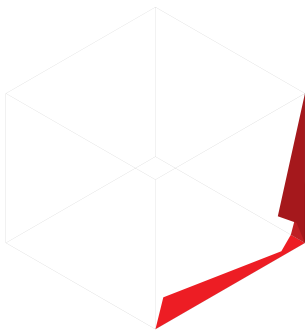


Studies in Material Thinking



VOLUME 13

**VISUAL / TEXTUAL: DOCUMENTING THE REALITIES
OF RESEARCH THROUGH DESIGN PRACTICE.**

PAPER 04

The Craft Technologist

Michael Shorter

ABSTRACT

Exploring the author's personal history as a maker and creative practitioner, this paper illuminates how he came to coin the term 'craft technologist'. Further, it demonstrates that a craft technologist approaches technology as a craft practitioner approaches a material: being reflective and experimental in order to refine their work, and crafting technology and objects with a reflective, creative and playful process—with the technology or craft not left as an afterthought. This is demonstrated through an examination of the author's own exploration of paper circuits—a project which was a turning point in his practice, combining the nascent technology of conductive inks on paper with the mindset of a craftsperson and technologist. It is hoped that this demonstration of a craft technologist's process will encourage a new breed of maker to create craft-centred artefacts with elements of intrigue and magic—and, most importantly, to be respectful of both the past and future of not just craft, but also technology.

KEYWORDS

Craft technologist, reflection, craft, technology, design, research, practice

STUDIES IN MATERIAL THINKING

www.materialthinking.org

ISSN: 1177-6234

Auckland University of Technology

First published in April 2007,

Auckland, New Zealand.

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STUDIES IN MATERIAL THINKING

is a peer-reviewed research journal supported

by an International Editorial Advisory Group.

The journal is listed in the Australian ERA 2012

Journal List (Excellence in Research for Australia)

and in the Norwegian register of approved

scientific journals, series and publishers.

The Craft Technologist

Introduction

Carey Reas took this idea a step further by creating the open source coding platform of Processing. This allowed a truly open sharing of code over the internet, enabling people to use existing code examples as well as build upon them. This, in turn, later led to the hardware equivalent, the Arduino, created by Massimo Banzi.

The practice and discourse of craft has a rich history, interweaving with that of art and design. In 'Dangerous Liaisons: Relationships between Design, Craft and Art', Grace Lees-Maffei and Linda Sandino (2004, p.207) describe the relationship between design, craft and art as 'an unstable territory of permanently shifting allegiances' and, further, that 'this is true of both the histories of these three sets of practices and the three families of discourse surrounding them'. That is, there seems no hierarchy between these practices—they apparently run in parallel, developing their own blurry paths. This suggests that definitions of craft discourse and practice can be quite ambiguous, changing depending on time, culture and place.

There is a less recognised but still important relationship between craft and technology. Gutenberg's printing press, one of the most significant inventions in the world, was born out of a craft practitioner's approach towards technology (see Jarvis, 2012). Without the goldsmith Gutenberg's forays into the world of printing, the printed book as we know it may not exist. It was his society-changing invention that allowed for the printing and widespread distribution of printed materials. Without this technology, education was not widely accessible and blueprints for the industrial revolution could not be spread. He was the godfather of open source (open source being a business model where the blueprints/code/designs for a product are distributed freely—allowing the consumer to be able to modify and build upon existing products).

When people used to ask me what I did, I always had to think for a while before inevitably giving an answer that I was never fully comfortable with. From the very first time I heard that question, I wondered if I would ever find a term that described my practice perfectly. I had studied product design, but didn't consider myself simply a product designer. My degree is a Bachelor of Science, but I am certainly not a scientist. I work with technology on a daily basis, but I'm not a technologist or engineer. Through my recent work I have started to see what I do as more of a craft (regarding the way in which I work with materials and technology), but would not consider myself a craft practitioner. I am creative with technology but I am no creative technologist—there is much more emphasis on the exploration of process in my practice for that term to apply to me (this is explained in more detail below). From these distinct terms—product designer, scientist, technologist, engineer, craft practitioner, creative technologist—I drew out the two that resonated the most and crafted my professional identity from their union. I am now proud and quite relieved, to call myself a craft technologist.

Craft practitioners will invariably define themselves and their work in a myriad ways. Most, however, will agree that a craft practitioner has a reflective and personal process concerning the physicality of a material. A craft practitioner has a deep understanding of not just a material, but a material's history. In addition to crafting a material they are also able to alter and advance materials through reflective and playful processes. With such focus on the materiality of craft, questions arise that are becoming increasingly relevant in our technology driven society: What if the material of choice is the Internet, electrical components ¹, electricity, digital signals or code? Can we use the same rhetoric? How would the use of these 'materials' fit into the practice, discourse and final outcomes associated with standard craft methodology?

¹ For my product design undergraduate degree show I created the Audio Shelf (see Figure 1). After four years I was still unsure of what I was or what I wanted to be; I was entirely unaware that with the Audio Shelf I had laid the foundations of becoming a craft technologist. Quite simply, the Audio Shelf was a stereo built into a shelf. The interface gave limited control: play, pause and skip. The volume level was controlled by the weight of the objects placed on the shelf; a light object like a pencil would give a low volume level and a heavy object like a stack of books a loud volume level. I was not only interested in sensors, but the way people used them. I would embed sensors that forced certain interactions to allow the control of devices. Just as a potter crafts clay, I was crafting interactions. At this point in time I was influenced by design research work by Daniel Rozin and the Curious Home project as well as classic design from the bespoke, narrative rich, Droog objects, and the meticulously detailed work of Dieter Rams.

The core interaction of the Audio Shelf was created by crafting sensors. I took sensors and experimented and played with them. I may have taken them apart or used them in unintended ways—but by doing this, I was able to gain a deeper understanding of sensors, quickly learning their limitations and where they could be pushed to in order to create interesting interactions.



Curious Home

*Ubiquity,
sensors,
aesthetics and
play*

*Materials, sensors,
actuators and magic.*



Daniel Rozin

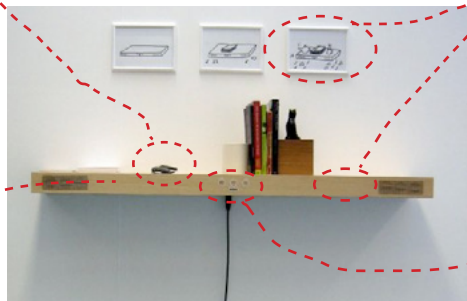


Figure 1. The Audio Shelf

*Materials
and
humour*



Droog

*Detail detail
detail*



Dieter Rams

The Craft Technologist

I would like to clarify what I mean by deep. 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. This is a way of gaining an empathic understanding of the digital as a material. I explore a technology much like a potter explores how far they can push clay as it is thrown on a wheel; they use their tacit knowledge and hands to discover how the material will respond, and how it can be coerced into a form that isn't easy for the material or process to achieve. When I explore a new technology I do so with my hands. By using your hands to manipulate, de-construct and explore the technology it is possible to gain an intimate understanding of how the technology works. When I am working I see technology not as a tool or a part, but a material that can be explored and altered.

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 understand its history and will work to a technology's limitations while simultaneously wringing it dry of creative possibilities. They will find new applications and affordances through questioning the aforementioned limitations. A craft technologist may not draw circuit diagrams or use equations the way an engineer would, but instead learns by doing, making mistakes and being reflective².

A craft technologist navigates and explores technology through traditional craft methods and processes. They play and craft with the materiality of technology. Studying the relationship between craft and technology is by no means a new area of research, but where previous studies predominantly focus on technology as a tool (Marshall, 2002, Bunnell, 2004). Craft practitioners will often regard technology in a pragmatic sense; a tool or technology becomes an extension of the hand (Marshall, 2002). But technology can be more than just a tool; it can also be a material. Tom Armitage (2011)

While this article recognises that the rationale and definition of a craft technologist isn't located in science and technology studies, there is a clear relationship to definitions of a 'positivist' technology definition in this context. It should also be noted that this 'positivist' positioning is arrived at using a critical feedback loop through reflective practice. Given the positioning of this article for a design and craft audience, I am deliberately keeping an academic distance between science and technology studies' definitions of social technologies—instead keeping connected to a language of 'technology' in general.

² As long as I can remember I have always worked with my hands (Figures 2 and 3), this stems from an intrigue into the way things are made and how they work. I know this because when I was given a new toy I would maybe play with it for a while, I would then go on to play with the box it came in as it would always have a million more creative functions than the toy itself; it could be a house, a car, a boat or a robot suit. After finding an infinite amount of uses for the box I would return to the toy to ask questions and gain answers. I had this fascination into the workings of most objects I owned as a child and I would want to gain a deeper understanding of not just how things worked but how they were made. I would



I remember not having any wheels for this cart. I ended up cutting circles out of a plank, working to the limitations of what I had around me. From this I learned a lot about the material; what it worked well for and not so well for. I was prototyping ideas from an early age!

Figure 2. The author prototyping a wooden cart.

Bringing craft and technology together from an early age.

This ties into my current old of research and will be explained fully in the upcoming case study.

From my experience anything can be crafted, including code and circuits. It is down to the mentality and approach taken—playfulness, creativity, exploration and reflection. This does not mean by any stretch that the craft technologist must have a high level of understanding of the technicalities of code and electronics; a basic understanding can allow you to craft existing code and electronic examples found online together. Someone can craft code and electronics without being a craft technologist. A craft technologist is as concerned with the physical as well as the virtual. They are concerned with craft, not just the verb, but also the noun. That is, there is a focus on the process of crafting rather than creating a craft object and the final outcome will look like a physical crafted artefact.

take the toy apart inspecting all its different elements (plastic parts, fixings, motors and other components), in my mind trying to understand how it would be made in a factory, figuring out the order in which it was constructed. This became the most interesting and educational aspect about most things I owned. I took apart everything from remote control cars to old radios. Even when I was given a new Lego kit, I would often ignore the instructions and try and figure it out for myself. At the age fifteen I was taking apart much more complex objects. I was given an old broken motorbike. After sourcing old parts from a scrap yard, I re-built the entire thing from scratch, including every part of the destroyed gearbox. As I jumped on the kick-start I was amazed that I had managed to get the engine turning over.



Figure 3. A re-purposed remote control car.

This difference between a functional and an experiential question is at the core of what a craft technologist is trying to achieve. They are crafting experience more than function.

I feel that ambiguity can allow for a varied and unrestrained approach.

I see Arduino and processing as a bridge between the tool and the material—these platforms are instrumental in the development of the craft technologist.

discusses how artists may use technology as a material in the article 'Technology as a Material', commenting that 'Materials have desires, affordances, and textures; they have grains. We can work with that grain, understanding what the material wishes to be, wishes to do—or we can deliberately choose to work against it. We must understand that grain and make a deliberate choice.' This idea of going with or against the grain resonates with the open source/hacking community. Platforms such as Arduino and Processing afford to be hacked and used in endless ways. The software and hardware can be coerced and crafted by the practitioner. A craft technologist will not begin with a design problem to be solved, but instead starts with a question. A craft technologist would not ask the question 'what happens when conductive ink is combined with paper?', but rather more open-ended and almost ambiguous questions, such as 'how can value be added to paper with conductive inks?' The first question may yield an answer like 'it makes an electric circuit'. The second question will evoke answers such as, 'it makes an electric circuit that enhances the user experience and creates an emotional bond between the user and paper'. This is precisely the type of insightful comment valued by the craft technologist as they seek to craft objects that evoke emotion and create connections on a deep level. This emotion and understanding is gained through a craft technologist's immersion with the technology by playing, crafting and reflecting—the basis for a craft technologist's process of reflect—play/craft—reflect (a process which is the author's own and is used to compartmentalise each stage of a craft technologist's methodology).

Reflecting on a question is only the beginning of a craft technologist's process, helping them gain insight and direction into where they want to take their practice. Reflection, as Donald

This process is a development of my previous, more product design-focused process of find, play, make and talk.

Schön (1983/2003, p.61) observes, is essential in gaining a deeper understanding into one's practice. Brigid Reid (1993, p.305) perceives reflection as an active and constant process, stating that 'reflection is a process of reviewing an experience of practice in order to describe, analyse, evaluate and so inform learning about practice'. 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 absolutely provides a better understanding of one's practice. Marilyn Daudelin (1996) narrows the focus to reflection's role in relation to learning, stating (p39.): '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'. Further, Daudelin suggests that reflection can be used as a tool to try and understand the future of a situation. The author further suggests that it may also lead to entirely new ideas—a creative technologist, for example, could use these reflective tools and principals to push a technology further. Reflection as a concept is a useful umbrella to hold over an entire practice or, where the craft technologist is concerned, over every stage of reflect—play/craft—reflect. Sometimes, however, concrete tools are useful. The author will expand on his personal reflective tools in the second 'reflect' stage of his process.

The next stage of the craft technologist's process, play/craft, will also help the practitioner reach better and more creative situations (Brown, 2008) though a much more hands-on³ and

³ I began my PhD in 2011. The initial scope of the PhD was to investigate potential new applications for the nascent technology of paper electronics. As I started to explore this bleeding edge technology, I quickly realised that traditional craft processes could be used to create paper electronic prototypes. It was through a trial and error process that I found it possible to screen print with conductive ink and create highly complex capacitive touch interfaces on paper. I fully embraced the craft practitioner that was secretly hiding inside of me and became intrigued by the usefulness of craft processes when dealing with the emerging technology of paper electronics. I welcomed a playful and reflective approach towards the limitations and potential of technology (see Figure 4.).



Figure 4. Experimenting with paint mixes for printing with conductive ink.

Just as my younger self found multiple uses for a cardboard box.

Playing is my favourite part of the craft approach.

Various dilutions of water were mixed with conductive ink. The resistance was measured with each iteration of dilution. It was hard to find a balance between viscosity and resistance; the paint needed to be runny enough to not dry in the screen-printing screen, but not so watery as to lose its electrical properties.

The squeegee: a traditional screen-printing tool.

An emerging technology in a very messy traditional craft environment.

Does a craft technologist hack or craft? Writing code from scratch is just like starting with a block of clay or wood; it is a blank canvas. The same goes for electronics, only now the circuit board becomes the canvas. There is a history of repurposing in craft; design collective Proog and Ron Arad certainly repurpose. The value is not the beauty of the object or the code, it's the way the code and electronics interact with the world and the rich experiences they create.

Reflect-play/craft—reflect is not a static, militant process. It is exible; each step welcomes returning to the previous, or temporarily jumping ahead. This is why it is important to remember that while play/craft is bracketed by reflection, it also undercurrents the process as a whole. Conversely, if moments of play/craft break into reflection, this is entirely welcome.

Crafting research through a physical digital object.

interactive experience than reflecting. By playing with a technology it is possible to explore new unthought-of, creative and unexpected uses. By playing you are learning by doing, or as David Kelley from Ideo would say 'thinking with your hands' (Kelley in Brown, 2008, 16:37). By 'thinking with your hands' you are connecting with the technology and gaining a tacit knowledge of what it can and can't do through a process of trial and error and learning from past mistakes. When playing, a craft technologist continues to meld the practice of craft and technology. They are careful to avoid reductive or simplistic actions such as embedding a technology in a crafted object, or vice versa. They practice craft and technology in a holistic manner.⁴

Upon completion of the play/craft phase, the craft technologist moves back to a reflective phase. This time, instead of reflecting inward, they reflect outward. Prior to this they were reflecting on the world, soaking up insights and information and questioning, now they are disseminating their product, and reflecting

⁴ In 2009 I became a research assistant on the Bespoke project (see bespokeproject.org.) On this project I furthered my work on the combination of craft processes and technology. This multidisciplinary project conducted research through insight journalism to help a deprived community to find their voice. This journalism fed directly into the design process and the outcomes were design solutions created with, and for, the community. During the initial research I was part responsible for designing a village fete that allowed us to gather insights (Figure 5). The objects in the fete were crafted to collect data on the local community. We built a giant strength meter; the community responded to questions by hitting the strength meter with a giant hammer depending on how strongly they felt about the question (Figure 5).



Figure 5. Crafting research through the Bespoke Insights Fete.

This is where my thoughts on the craft technologist's skill set stem from.

The Wayfinder took traditionally crafted objects into the digital world. By externalising this idea we allowed the community to pass comments and react to the design.

Outward reflection is a form of dissemination and can be inspiration for other craft technologists. It also allows the practitioner to step back and reflect on their own practice.

These platforms allow the world to see what I am doing and 'speak back' to me through comments.

It was during this project that I realised the breadth and scope of what craft can be; this was down to meeting and working with Justin Marshall, a digital craft practitioner and researcher based at Autonomic, Falmouth University. Justin and I worked closely together to produce design responses to the insight journalism research. The two prototypes we worked on were the Digital Buskers and the Wayfinder (Figure 6). These two prototypes were crafted both physically and digitally. The Wayfinder took local event data and displayed it through three digital signposts in the community. The Digital Buskers acted as a physical MySpace, taking local grime rappers' music, and playing it from life sized statues of the artists.



Figure 6. The Bespoke Wayfinder.

on the finished artefact and reactions towards it. Donald Schön (1987/1990) suggests that externalising ideas allows the world to react back to the practitioner. This is undertaken either on a personal level, having one to one discussions about the work or, in a more public manner, by presenting work in galleries, in talks or online using services such as Instructables, Twitter or Instagram. Schön recognises two types of reflection: reflection-in-action and reflection-on-action. The craft technologist predominantly uses reflection-on-action, taking stock of situations after the action. They may use the media outlets suggested above. Figure 7 details the full process. Now that the craft technologist's process has been outlined it is important to make a distinction between the nuances involved with the practices of engineering, craft, design, creative technology and craft technology.

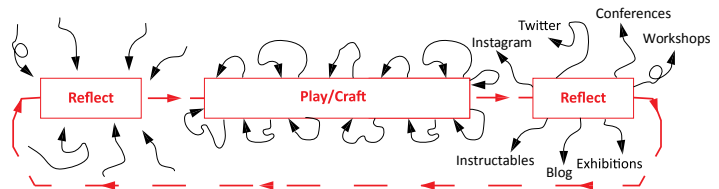


Figure 7. Diagram showing the craft technologist's iterative process. The black arrows show the flow of reflections feeding in and out of the practice. During the initial stage the craft technologist reflects in and out of the practice—collecting thoughts and insights. During the play/craft stage they reflect on their own practice. The final reflect stage sees a practitioner reflect outward by disseminating their work and receiving feedback.

These T-shaped practitioners are all professions that I may have previously considered identifying myself with before realising that I am in fact a craft technologist.

Craft technologists have a deep understanding of technology, they know its history allowing for them to try and know its future. The craft technologist plays with technology, embracing its limitations and being creative with it.

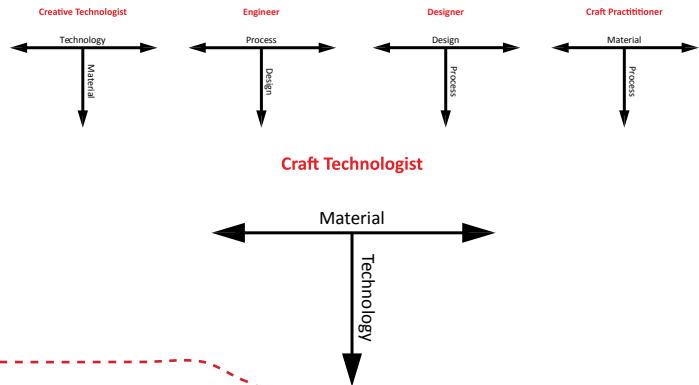


Figure 8. T-shaped practitioners showing the broad and focussed skills of each.

Kim Clark and Steven Wheelwright (1994) discuss the importance of the t-shaped practitioner; above (figure 8) are t-shaped diagrams created by the author to help clarify the difference between a craft technologist and a creative technologist, engineer, designer or craft practitioner.⁵

⁵ I have always described aspects of what I do as craft; whether it is crafting interactions through products, behaviours through interventions or questions through research objects. I feel that this path has led to where I am now crafting technology. Through my life there has been a constant interplay between engineering, design, technology, research and craft. These disciplines have not only come in and out of focus, but also blurred during my practice (see Figure 9). Recently craft, technology and design have all become my focus, not as separate strands but as a blurred amalgamation of all three. Technology or design are not afterthoughts, they are working together with craft processes. One thing that has always remained constant throughout my practice is that I learn by doing. I use my hands to understand the world, test out ideas and craft ideas and objects. By learning and doing with my hands I connect to whatever material or technology I am working with; it's this haptic and tangible way of working that allows me to convey my ideas physically. It is this method of working with physical materials in a reflective and thoughtful manner that forms the backbone of a craft practice.

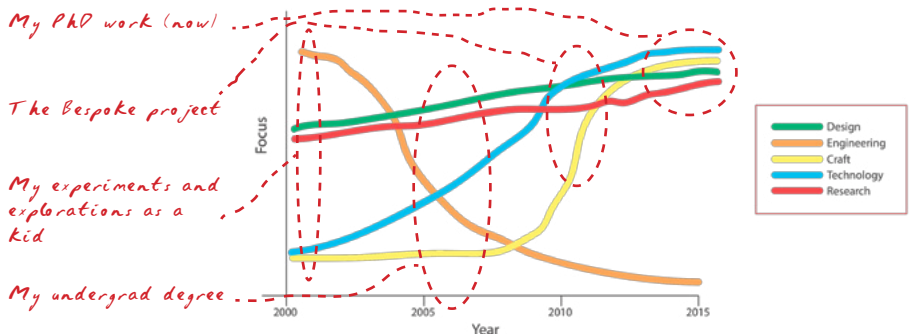


Figure 9. Diagram showing the ever-changing focus of my practice.

Here I am trying to de-blur the boundaries of similar practices. It feels like these boundaries have blurred over time as new methods and technologies have brought different practices closer together.

You'll recall our previous discussion of the blurry boundaries between the disciplines of craft, design, technology and art. These indistinct and shifting boundaries are accommodating of the craft technologist's desire to pull from all four—viewing hazy boundaries as aiding in the freeness and openness of their practice. Solid boundaries can sometimes be barriers to creative exploration.

The two most similar practices are those of the creative technologist and the craft practitioner. A creative technologist is a practitioner whose skills comprise of research, fundamental development, systems engineering and specific development and design (Kelly, 1950). The horizontal axes in figure 8 show the broad skill set of the practitioner and the vertical axes show where the practitioner delves deeply into a specific subject.

The below diagram (figure 10) illustrates the subtle differences between a craft practitioner, a creative technologist and a craft technologist. Both a craft practitioner and a craft technologist concern themselves with play and reflection in the exploration of a material or process. They each concern themselves with play and technology to explore applications and design solutions. However, it is only the craft technologist who concerns themselves with play, reflection and technology to explore and craft with the materiality of technology.

It does not matter whether you take a ground up approach or hacking (copy and paste) approach, as long as the practitioner is crafting with technology, in an understanding and respectful way, with an element of physicality in a reflective and playful way they are a craft technologist.

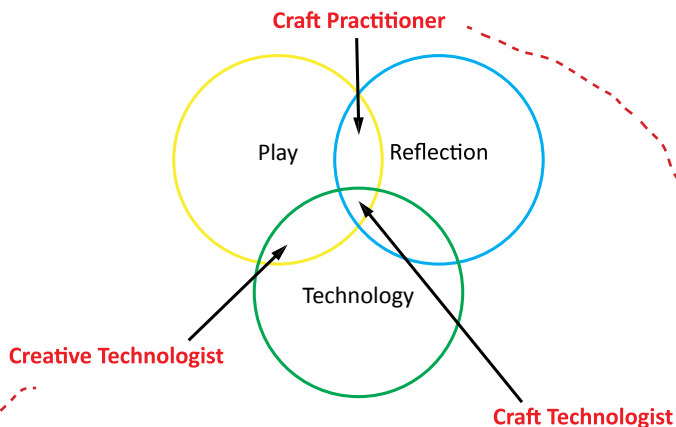


Figure 10. Diagram showing the relationship of key skills associated with a creative technologist, craft practitioner and a craft technologist.

A creative technologist will have an element of reflection in their practice but I do not regard it as a key skill as it is with a craft technologist.

A craft practitioner may have an element of technology in their practice but I do not regard it as a key skill as it is with a craft technologist.

Paper is one of the most important building blocks of society as we know it today. Paper created the foundation for the Internet; it influences modern technology heavily. Just think of the web 'page' or the i'Pad'. The convention of communicating through a paper medium is everywhere.

This exploration allows me to have a full understanding of the old.

Experimenting with what conductive ink can and can't mix with.

Experimenting with paper interfaces and questioning which paper interactions can have value added to them with conductive ink.

Paper Circuits: A Case Study

What would a craft technologist's exploration of the nascent technology of printed electronics result in? Printed electronics, sometimes referred to as plastic or organic electronics, are circuits created from semi-conducting organic materials as opposed to inorganic semi-conductors (PELG, 2012). Printed electronics allow for circuits to be printed on almost anything—the potential for this technology is endless. Printed electronics is a young field, with many of its uses still being discovered. As such, I identified it as a good candidate for the craft technologist's process of reflect—play/craft—reflect. In this case study, I demonstrate the craft technologist's methodology as being highly effective with emerging technology. Throughout this study I discuss the process in the first person as this is my research practice.

Reflect

I discovered that technologists and engineers were exploring printing electronics onto paper. It was this realisation that technology-driven fields were turning their sights on paper, a traditional craft material, which spurred me to take the investigation of printing conductive ink on paper further, approaching the investigation as a craft technologist. I began the initial 'reflect' stage of the process by delving deep into everything I could find on printed electronics—conducting interviews with printed electronics companies and exploring the history, future concepts, production techniques, development and social implications.

The written word could be printed on anything, but paper was chosen as the universal medium. Paper is cheap and easy to produce. It is lightweight, flexible, and an all-round versatile medium. Keeping my freshly developed craft technologist process at the forefront of my mind, I chose to explore the implications of printing not just content but circuits onto paper—suspecting that I could give paper added functionality and potentially craft a highly engaging experience. This initial 'reflect' stage was highly investigative. I



Figure 11. Experiments with conductive ink.

Mixing
with jelly

The effect
of heat

Resistance vs.
dilution with water

Folding
switches

considered paper's materiality, pervasiveness and uses in various industries: music, literature, news, advertising, packaging and art. During my exploration of paper's history I was careful to consider its effects on society and technology. I interviewed experts on paper, and visited traditional paper factories. When I felt myself fully saturated with both the current and historical landscape of paper and printed electronics, I was ready to play and craft.

Play/Craft

Paper circuitry is the combining of conductive ink and electronic components on standard paper to create interactive devices.

Exploring paper circuitry with my hands was a satisfying and revealing activity (Figure 11). I conducted experiments around the properties of conductive ink, asking questions such as: What can it mix with? What can't it mix with? How does this affect its conductive properties? How can it be combined with paper to create interesting interactions? What are the different ways of printing with conductive ink? What other technology can it be connected with to create more complex inputs and outputs? What are the methods of connecting paper circuits to other devices? What are the different ways of 'soldering' components to the paper and ink? Some of the more significant results from this exploration can be found in 'Practical Notes on Paper Circuits' (Shorter et al., 2014). These questions were answered through playing and crafting with paper circuitry within the craft technologist's process and the result was the creation of the Invite prototype (Figure 12).

Paper is often used as a call to action. Invitations, for example, are mailed out, taken to events and exchanged for experiences. They can be wonderful things with crafted affordances; graphic design, size, paper stock and content are all considered. A paper invitation can be more powerful than an e-invitation, or 'e-vite' (KentLyons, 2010). I questioned what would happen if the physical

This paper summarises my thoughts after three years of experiments including notes on sensing, printing, soldering and connecting.

This is due to paper's materiality and intuitive nature. We know what to expect from it; it is reliable and easy to use.

Hardware box containing the Arduino

Bespoke crafted bulldog clip for intuitive connection, maintaining the visual language of paper.

The Invite printed on normal paper with conductive ink.

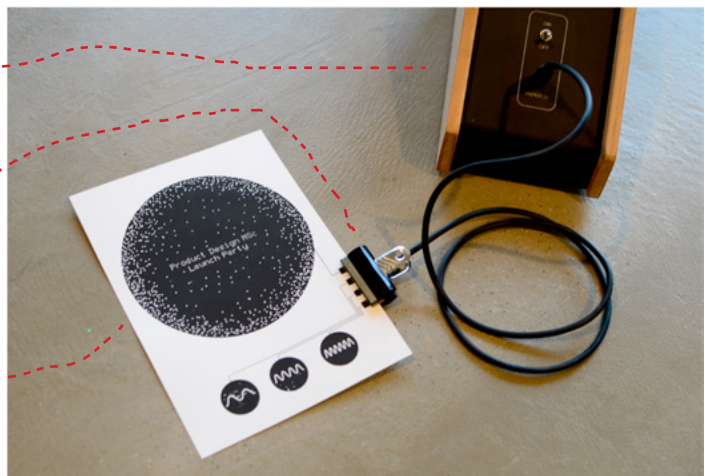


Figure 12. The Invite

This paper offers a detailed overview of how the Invite was crafted.

The craft electronics company Bare Conductive discovered that conductive ink could be used as a distance sensor by playing with capacitive touch. I decided to harness this property to create a Theresmin style prototype.

The Arduino is a tool that allows for the fast creation of prototypes. In this case it allowed complex digital behaviours to be given to paper in conjunction with conductive ink.

invitation's careful aesthetic considerations were combined with paper circuits and my answer was the Invite prototype (Figure 12). The Invite was screen printed with carbon-based conductive ink (Shorter et al., 2013). It contained no hardware, giving it the appearance of a normal printed piece of paper—however, when plugged into an audio system, the Invite transformed into a musical instrument.

The Invite interface allowed control of audio output in two different ways: pitch and frequency. The large printed circle used capacitive sensing to create a distance sensor. The distance a hand was from the printed area determined the pitch of the sound. The three smaller printed circles controlled three different frequency settings. This also used capacitance, but this time as touch buttons. To sense what part of the paper had been touched, the base unit that the Invite plugged into contained an Arduino. I crafted a bespoke bulldog clip to connect the Invite to the base unit. Throughout the entire play/craft stage of the process I reflected on every decision I made both in and on action through keeping a sketchbook of notes and questions, recording videos of prototypes and taking photographs. These reflective tools helped me take a step back and consider why I was making certain decisions.

Reflect

I observed that adding paper circuitry to an invitation resulted in increased curiosity, intrigue and play—important outcomes to consider when seeking to add levels of interactivity and physicality to a piece of print. With the addition of paper circuitry, the Invite was given intriguing new affordances that did not detract from the traditional affordances and experience of paper. The experience of an invitation was boosted as the Invite now afforded a musical interface. Creating this prototype with paper circuitry meant that the Invite could still maintain existing social interactions such as mailing, carrying around and being exchanged at an event. This case study was respectful of paper's history, materiality and social context.

Many lessons were learnt from this prototype: the interface was not as intuitive as it could be, the printed line thickness was too thin for the reliable electrical carriers and there were issues with capacitance grounding. However, the bulldog connection method proved very successful, and the price of printing the flyers was

We know that a craft technologist thinks, learns and makes with their hands and that they are concerned with the physicality and materiality of both materials and technology. The result of this learning-through-making is frequently prototypes. Lim et al. (2008, p.7:2) comment in The Anatomy of Prototypes: Prototypes As Filters, Prototypes As Manifestations of Design Ideas that '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'. Prototypes then, are extremely useful to a craft technologist not as a final design solution, rather as part of the process; their creation inherently calls for the asking and answering of questions and the thorough exploration of a technology.

Magic and intrigue are two important factors to consider while crafting an engaging experience; an intriguing quality is similar to a magic quality. People turn a sheet of paper over in their hands, amazed, no longer content of what it actually is.

relatively cheap. The 'magic' was well received—users struggled to believe all that was on the paper was ink and would pick up the Invite to make sure it was a piece of normal paper. The lack of wires or standard components threw people's preconceptions of what an electrical device or circuitboard should look like. The Invite's circuit looked more like a piece of graphic design than a traditional circuitboard. By achieving this magic quality I succeeded in crafting an emerging technology to give users a rich and meaningful experience. These reflections were kept in mind for the next iteration of the prototype: 'Playing Paper' (Shorter et al., 2013).

This next iteration of the Invite improved upon the printing process, trace line thickness, interface, graphic design and audio output.

Discussion

The activity of crafting is similar to an adverb. Just as an adverb modifies the meaning of a word, a craft technologist is modifying the materiality, purpose and meaning of a technology.

To recap, the important points to remember when considering a craft technologist's practice are:

- They use the process of reflect—play/craft—reflect.
- They learn with their hands and by playing; this leads to a tacit knowledge of their material.
- By going deep into their subject matter they learn 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.
- They understand craft as a verb as well as a noun.
- They use prototypes to externalise their ideas, disseminate and reflect on their practice.
- They aspire to crafting magical and intriguing objects through experimentation with materials and technology.

CRAFT
(noun)

CRAFTING
(verb)

I introduce the craft technologist as a new breed of maker, one that enables for technology to be approached in a playful and reflective 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 and the tangibility of physical crafting, it is this magical and intriguing quality that can differentiate between a craft technologist's practice and other practices. The familiar artefacts of craft blended with the mystery—and, arguably, inaccessibility—of technology creates an enthralling and engaging user experience.

By dressing technology in a comfortable guise (in this case, paper) the craft technologist has successfully removed any intimidation certain users may have felt, and is allowing users to not only access technology through a comfortable form, but also think about this known material in new ways. This newly-defined practice

My practice over the last fifteen years has led me to become a craft technologist. This is not to say that you need to go through all my life experiences to become a craft technologist; there are plenty of us out there approaching technology with the craft practitioner's mind set.

Reflecting in action can be a hard task. I found it easiest to capture photos and notes periodically during my practice. I would not be playing and reflecting at the same time, but rather reflect every half hour or so whilst playing or crafting.

A craft technologist can be seen to be some sort of custodian for designing and making an appropriate future of objects and materials as technology progresses rapidly.

will invariably lead to viewing technology in innovative and interesting ways by basing an exploration of technology on the rigour of the craft process.

The craft technologist is a maker who uses technology as his/her material and explores this material through traditional craft processes. To me, this is the best of both worlds. It describes my practice perfectly and it has helped me to map out my process as a maker. This hybrid maker draws influence from different disciplines and uses these influences to craft technology in fresh, unintended and well-considered ways. Effectively, through this paper, I am arguing that the practice of craft can be a powerful way of working, and its openness allows it to be adopted by other disciplines. The Invite was a piece of craft technology. The process of reflect, play/craft and reflect allowed for the Invite's technology to be explored in a deep, reflective and playful way. The outcome of this process allowed for a well-considered, respectful, explorative prototype that not only used the technology of printed electronics but also paper in an engaging and stimulating manner.

It is this craft method of reflecting on actions that allows for continuous learning. Constantly reflecting during every stage of the design work allows for a deeper understanding of why each decision was made, and ultimately better the design process. Schön (1983/2003), Reid (1993) and Daudelin (1996) all agree on the importance of reflection when it comes to making future decisions. This reinforces why reflective practice is an important method to bear in mind when designing with emerging technologies and ideas. We must first deeply understand past experiences and technologies before we can meaningfully design future technologies and experiences.

Concerning playing and crafting, the prototype has never been so crucial a testing ground for expanding on current knowledge and moving into the unknown. Lees-Maffei and Sandino (2004) suggest that the role of prototyping cements the importance of externalising ideas. Further, Tim Brown's thoughts on learning by doing (2009) reinforce the knowledge gained by working with your hands to understand your practice on multiple levels.

As technologies are advancing at a vast rate it is only too easy for makers to get carried away and create devices without thinking sufficiently about future implications. For example, with the Internet of Things, it is easy to try and connect everything to the web, but what does this really mean for society? Will it take us into some Orwellian dystopian future? A craft technologist positions his/her self so that they fully understand the past social implications of a technology in order to try and fully understand its future implications allowing for them to craft a respectful and considered future.

Ezra Pound, literary critic, poet and founding father of the Modernist literary movement, considered the classics to be fundamental. Along with T. S. Eliot, Pound sanctioned the knowledge and understanding of these texts as a necessary keystone to future literary creation. He thought it was impossible to create anything of value if the history of that field or movement were not thoroughly

considered. These ideas can be applied across numerous disciplines and fit well with the goals of the craft technologist. The best potential for future development, and therefore emerging technologies, will come from learning the failures, successes, motivations and inhibitors of the past.

The Modernists changed western society from the cafes of Paris, waving texts by Homer, Aristophanes and Sappho. Will the current trajectory of craft and technology prototyping shape society similarly? As we move into an increasingly visual and digital age, can products and technologies affect the world the way words have in the past?

We are seeing platforms emerge that promote and enable open play such as Arduino or Processing. It is this shift towards open source technology that can unlock the potential for a worldwide community of craft technologists that will craft our future world.

Acknowledgements:

My thanks go to the community at the All Makers Now conference in Falmouth, UK (2014) for presentations and conversations that helped foster and develop my thinking towards the role of the craft technologist.

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