Dr Katie Bunnell and Dr Justin Marshall

Developments in post industrial manufacturing systems and the implications for craft and sustainability

www.autonomatic.org.uk

Key Words

Digital Design Production, Digital Media, Customisation, Craft, Sustainability

Abstract

This paper will discuss how the developments in digital production technologies, when coupled with advances in digital communication and networking, have the potential to transform not only the way things are made, but also underlying business structures, market economies and ultimately the structure of society. The capabilities and possibilities of these technologies will be illustrated through examples in professional practice and in individual research and knowledge transfer projects carried out by the Autonomatic cluster at University College Falmouth. These examples will be used as the basis for questioning the role of craft in new modes of production which integrate sustainable practices and Information Communication Technologies (ICT).

An optimistic vision of future manufacturing is that Digital Manufacturing and ICT will facilitate distributed and localized production, reversing the trend for centralization and urbanization created by the 1st industrial revolution. Rather than completed products being transported across the world from wherever labour is cheapest, digital design data will be sent closer to the customer base, be regionally tailored to local or personal requirements and produced only when needed. Therefore the energy and resources associated with storage and transportation will be removed from a products ecological footprint. Costs will reduce, while diversity and variety will increase and through these changes new business models, based on skilled digital crafting and bespoke production, will emerge.

Whether this vision becomes reality is difficult to judge, and will to some degree be dependent on economic and ecological change. We can already see the broad and significant impact of digital technologies on the way things are made. Within the Autonomatic research cluster at UCF we are exploring ways of integrating digital and hand based making processes and our practice-based research raises questions about the role of craft in post industrial manufacturing scenarios: how can independent makers situate themselves in this future making scenario? Should they situate themselves against this digital revolution, or recognise there are characteristics which digital making and traditional craft making share, and through this make a positive contribution to shaping the ways in which digital technologies can be developed and deployed.

Introduction

In his book, Theory of Design in the First Machine Age, Reyner Banham describes how in the first thirty years of the 20th Century, artists, designers and architects developed a vision of a future where machines would enable man to distance themselves from the repetitive, machine-like handicraft that had previously inhibited their spiritual fulfilment[i]. In contrast, a 21st century vision of design might be characterised by a concern to re-connect people with the processes of designing and manufacturing through their involvement with digital 'machines'. In this vision, people are empowered through their engagement with design processes to get involved and influence the creation, selection and use of personal, social, and economic resources; to be part of a *Digital Economy*[ii] that uses information and communication technologies in the transformation of their lives and the lives of others.

In the world of media, the development of digital tools and networks enables consumers to become producers: anyone can create, produce and distribute their own writing, films, music, documentaries, art. This is now beginning to happen in the world of designed objects.

The first section of this paper provides a review of a selection of companies who are exploiting the potential of digital technologies and online interaction with users in variety of ways. These companies provide examples of new ways of designing and making things through various combinations of e-commerce, web 2.0[iii], Rapid Manufacturing (RM)[iv] and other digital production technologies[v], evidencing the ways in which digital technologies are challenging established manufacturing methods, market definitions, and modes of consumption of design products.

The second part introduces two interactive websites, Automake and Autochina developed by the authors in collaboration with software programmers and web designers. In this section the authors offer insights based on their own experience of working on these projects, questioning their roles within them as designer-makers and discussing the potential future development for these sites from their perspective.

The paper concludes with some discussion about the possible relationships between craft practice and new modes of production, with specific reference to the potential to develop more environmentally sustainable modes of production based on a model developed by Olivier Geoffroy founder of Unto this Last.

Branded Online User-based Customisation

Online customisation is now offered by many global corporations: Nike, Adidas and Fiat[vi] amongst others offer the ability to select from a variety of options on styling and detailing of products enabling consumers to personalise their purchases. In the online design environment, the physical design of a trainer for example, for the most part remains the same, but colours and materials can be selected and personal motifs added at little extra cost to the consumer[vii]. From a design perspective these opportunities present a limited and stylistic view on customisation. For the consumer this personalisation of established brands can add value for both individuals and groups, and the process of customising your product can allegedly bring a creative dimension to the shopping experience.

Customisation through Rapid Manufacturing (RM)

In addition to customisation services offered by established global brands with reputations and economies built on mass production technologies, there are a

rapidly growing number of companies built entirely on the use of digital technology and whose central offering is customised product.

The Materialise Group, a global company set up in 1990 as a joint venture with the University of Leuven in, in Belgium, have been key players in the development of innovative software and hardware solutions for customised industrial and medical design applications. Having established a technology business in these markets, they launched a new division in 2004, **Materialise MGX**[viii] , www.materialise.com, to offer innovative made to order interior, architecture and fashion design products. Working with high profile contemporary designers they have created a collection of unique products that exploit the capabilities of RM technologies and materials. These products are characterised by complexity in form, detail in surface and often translucency in material exploited for lighting purposes.

Freedom of Creation[ix]**,** www.freedomofcreation.com (FOC), was established in Helsinki, Finland in 2000 by Janne Kyttänen a graduate from the Rietveld Academy in Amsterdam. Kyttänen based FOC on his exploration of the use of RM in design production and the logistics of global product distribution. FOC Amsterdam was established 2006 and in 2009 FOC consists of a team of recent graduates and student interns designing lighting, furniture, jewelry, and household and fashion accessories. Like MGX, FOC products exploit the complexity, flexibility and translucency of RM production materials and methods. In addition to an aesthetic sensibility, FOC also have a future vision of for design and production that has an environmental agenda:

'*We believe in a future where products are just data and are distributed like images or music over the internet today. In our future there is only virtual storage and our tangible products can be recycled to whatever your heart desires*.'

Criticising the pollution and waste associated with mass manufacturing, they believe their '*approach will have a tremendous effect on carbon emissions on a global scale'. 'You will only have to produce what you need, there is hardly any transportation and all the stock you have is virtual'*.

Currently most of MGX and FOC's products are made of thermo-plastics associated with RM technologies, which are not easy materials to recycle and are derived from petro-chemicals. Some items in the FOC collection use silver plate on plastics and some are even made of solid gold, perhaps indicating the designer's ambition for personal emotional attachment and longevity. A recent collaboration by FOC with Fresh Fiber on personalized i-phone covers has specifically involved the use of recyclable organic material.

Design your Own

There are a growing number of internet based businesses that specifically offer opportunities for individuals to create objects through the use of digital production technologies and to market and sell these objects through e-commerce. These companies specifically use Web 2.0 technologies to facilitate individual creativity that can be shared within a networked social and economic community. For this reason, these online Design Your Own companies are perhaps of most significance to craftspeople and makers.

Fluidforms[x], www.fluidforms.com, based in Graz, Austria, is a company developed through the collaboration of two design graduates, Hannes Walter, designer and Stephen Williams, software programmer, and has another take on customisation. Using Web 2.0 technology and a variety of digital production

technologies, they have created a business that offers consumers a variety of digital tools that enable them to get involved in the design process. Their website offers a range of products whose final forms can be influenced through a variety interventions including: changing the shape of a salt/pepper mill and selecting the type of wood that it will be made from; entering a ZIP code to create a wall light from the topography of the place of your choice; and beating a custom lamp out of a virtual punch bag. In addition to this they individually manufacture these products using a variety of digital production methods that enable the use of a wider variety of design materials than RM technologies used by FOC and MGX, and which often involve hand skills in finishing. Even so, according to their website it takes approximately 14 days for them to manufacture and deliver your design to your door. Fluidforms actively promote the value of craft and their business model gives credence to the consumer as a creative individual, empowering them to make choices, within a more extensive range of design parameters than the Adidas website for example, but still limited to personalisation rather than more complex design issues. They market their products entirely through their website tapping into and creating viral consumer networks.

Shapeways[xi], www.shapeways.com, based in Eindhoven in the Netherlands, are 'passionate about creating' and offer a service that provides support for creating and printing 3D CAD designs at very competitive prices. You can upload a CAD file you have created yourself and/or you can use their online tools to create or modify files. Their service involves a community of users sharing experience, and outcomes through a gallery where objects can be to ranked and valued by the community and designs can be sold or given away.

Also based in Eindhoven, **Studio Ludens**[xii] www.studioludens.com, is a partnership between industrial design graduates Wouter Walmink and Alexander Rulkens. Studio Ludens bring together the whole package of design, manufacturing, marketing and selling. Their mission is to give people the creative freedom to design their own products. They want to provide their customers with an opportunity to express their creativity, to be playful (ludic) and get involved in designing through the use of digital design tools. *'Apart from being passionate about good design, we are foremost passionate about people. We want to give them the tools to create by using our skills as designers and our knowledge about the production process'.*

Somewhat disappointingly, their website seems to revolve around tools that enable users to play with some relatively complex and visually intriguing 2D geometry which is then applied to the production of laser cut coasters. Their online tools enable users to engage with some complex CAD capabilities without the barriers of skill and cost associated with commercially available CAD software.

Nervous System[xiii] www.n-e-r-v-o-u-s.com, was founded in 2007 by MIT graduates Jessica Rosenkrantz and Jesse Louis-Rosenberg. Nervous system enables the creation of experimental jewelry, combining non-traditional materials like silicone rubber and stainless steel with rapid prototyping methods. Nervous system find inspiration in complex patterns generated by computation and found in nature, and create designs through an iterative and experimental process. After brainstorming an initial concept they write a pattern generating algorithm through which they continue to explore their ideas and eventually create a finished product using inexpensive materials and ethical production process including Rapid Prototyping. They make these interactive applets available for anyone to use and release their code as open source to encourage others to work

in this way. These applets enable user to engage with more sophisticated 3D geometries than other online design tools available on the other sites reviewed in this paper and this more sophisticated generative form manipulation would seem to result in more visually interesting design outcomes.

Ponoko [xiv], www.ponoko.com, whose strap line is 'the world's easiest making system' - is an online marketplace for making, selling, commissioning and collaborating. The company launched in 2007, and has its origins in New Zealand. Ponoko claims to '*provide the world's first digital making system that means these product designs can be priced instantly online and made locally, as close to the point of consumption as possible. Our website connects consumers and retailers with designers, manufacturers and materials suppliers to deliver goods, made-on-demand direct from digital design files in the greenest way possible. Our service saves 90% of the time and 50% of the costs to make and market goods, while retailers get a zero investment / zero inventory wholesale service and consumers get individualized goods*'.

The Ponoko brand is not concerned with promoting individual designers or even specific kinds of design product. They specifically set out to provide an open digital designing, making and selling service for micro-manufacturers and existing professional makers. They are in the process of setting up a worldwide network of production bureaus, in order to achieve their vision of localised production.

Amateur designers challenge professional design through the use of the internet

Mydeco[xv], www.mydeco.com, also goes some way to reconfiguring the relationship between consumer and designer by enabling customers to create and buy their own visualised interiors. Significantly at mydeco, the work of amateurs can be seen alongside new designers, as well as small scale and large scale design labels. Artists and sole proprietors also get in on the act, displaying one-off products in mydeco's design boutique.The site also provides makers of furniture, fabrics, lighting fixtures, and decorative objects with a powerful new marketing tool. By aggregating 1.5 million products from more than 650 sellers, the site offers buyers a vastly larger selection than local design showrooms or even big-box superstores.

Within the specific area of craft production, **Etsy**[xvi], www.etsy.com, have evolved a commercially successful online digital community of makers, sellers and buyers of handmade products. This community was founded in 2005 and has spread to 150 countries with hundreds of thousands of sellers. They value human to human interaction and promote peer to peer exchange of goods and skills as a meaningful, ethical and economically viable alternative to mass production.

'Our mission is to enable people to make a living making things, and to reconnect makers with buyers. Our vision is to build a new economy and present a better choice: Buy, Sell, and Live Handmade'.

Etsy also offer a service where people can describe what they want and makers can pitch their offers in response as well as *Creating Labs* where people can learn craft skills. Sites like Instructables, www.instructables.com[xvii], Makezine[xviii], www.makezine.com, and Knithappens[xix], www.knithappens.com, provide instructions and video demos available through YouTube for making your own stuff that you can then sell on Etsy. While Etsy welcomes the participation of the amateur craftsperson and promotes the value of craft as a process as well as a product, they are in fact providing a service that enables people to develop financially successful craft based businesses.

The future vision of these internet companies is based on continuing technological innovation that will increase flexibility in production processes in relation to customers' needs and desires. Within this vision there's a particular social and economic construct around a demand for individualised products. Whether or not this is a tenable construct on which to create a sustainable business, or whether we really need or desire this level of personalisation, remains to be seen.

These companies clearly believe they are doing something revolutionary and important in the changing world of products and services and at present they are only scratching the surface of what they believe will be possible in the future. They showcase ways in which designers are able to exploit digital technologies to create designs with innovative aesthetic qualities and in some cases new functionality as one-offs or as products that can be made on demand, and perhaps most importantly they are showing us ways in which the relationships between consumer and designer are diversifying.

These changing relationships raise questions about the role of the professional designer. With access to a wider range of goods and rapidly growing opportunities to bring personal styling to them through extended choice and some simple interactive tools, everyone can be a DJ (Designer Jockey): mixing things the way they want to. Perhaps inevitably an increase in choice or ability to influence design outcomes also leads to the need for more guidance, and less consumer confidence related to lack of product endorsement through brand and designer labels. Etsy would argue of course, that we don't want to be told what to buy, that we can make our own choices. FOC and Materialise MGX do not currently offer online design tools that enable consumers to participate in a design process, preferring to headline and value the skills of named designers on their sites and to offer unique products that can be made to order as and when required. Fluidforms and Studio Ludens base their business on promoting the idea that people can be creative in their own right, while Nervous system are focussed on designing tools that facilitate their own production, while making those tools available to others.

The idea of craft is implicit in these businesses in terms of enabling individual decision making, facilitating peoples' creativity, as well as in the 'crafting' of software for creating objects. Ponoko are distinct from these other companies in that they offer very limited interactive tools and have a clear focus on offering a whole service aimed at designers who maybe aspiring or established.

Autonomatic Projects

As practitioner researchers exploring the relationships between craft and digital technology we have been independently involved in two projects in the last 3 years: Automake and Autochina have involved us in developing online interactive tools that enable users participation in the design process.

Automake[xx]**,** www.automake.co.uk

In 2006 Marshall was asked as a practitioner-researcher in digital craft to take part in an ongoing collaborative research project exploring the use of generative digital systems and digital production technologies to create unique design objects. The first phase of this project, FutureFactories[xxi]**,**www.futurefactories.com, was initiated by Dr Paul Atkinson at the University of Huddersfield, and involved the PhD work of industrial designer Lionel Dean, and collaboration with software programmer Dr Urtu Unver. In this

extension of the project, Atkinson was particularly interested in investigating a craft researcher's approach to generative design systems.

Marshall's work in the field of digital craft production had specifically involved him in developing 2D tessellating patterns for ceramic and plaster tiling systems. Building on this previous interest he was excited at the prospect of collaborating with a computer programmer on developing algorithms which would allow the generation of 3D tessellating forms and structures.

Working collaboratively with Unver, Marshall became aware that the computer based design systems they were developing had potential to go beyond a set of automated procedures which would extend his own design capabilities. This shifted his interest to developing software that would allow others to engage in a design process and create their own virtual forms. His role in the project mutated from that of a craftperson excited and engaged in developing generative systems for the development of his own work, to craftperson interested in how online design tools can begin to challenge definitions of authorship, concepts of provenance, characterisations of practice and models of consumption.

Marshall was really interested in creating tools that would provide users with a greater freedom of control over a set of variables within the system. This increase in creative possibility inherently created greater complexity in the system resulting in greater potential for failure in use – a concept that craftspeople are familiar with. A complex set of tools and instructions for use had to be developed and these became much more significant elements of the project than initially expected. The development of user feedback on their experience of the tools also remains to be built into the online system.

The project resulted in a working beta version of the software available for use online. Data files generated through interaction with the system are automatically emailed to Marshall who can then digitally reconstruct the objects and produce physical artefacts using RP technology. An embryonic system for indvidualisation of forms has been developed. However, the change in emphasis from personal practice towards a form of co-design presented both researchers with technical and conceptual challenges and raised more questions than could be addressed within the scope of the project.

In terms of Atkinson's investigation into a craftsperson's approach to designing and making through generative digital systems, Marshall believes that his approach was to 'craft' a system that recognised peoples prosaic urge to create, personalise and participate. In contrast to this Dean's work for FutureFactories successfully uses generative systems and purposefully limits user interaction to create objects that are recognisably authored by Dean. Automake attempts to create a greater sense of participation in the process of 'crafting' digital artefacts, blurring the sense of authorship of any objects created.

Marshall's believes his interest in developing an open and creative system for users contrasts sharply with Dean's desire to constrain user involvement. He proposes that these differences in approach are born out of some important distinctions between craft and design practices, saying:

'The interactive systems that are now available online, challenge the role of the professional designer- replacing their skills with those of amateurs. Design as a professional activity is well established and can possess an authoritative certainty in its own values and judgements. This may result in an unwillingness from designers to relinquish control over processes which they feel they are master. Craft cannot claim quite the same ground and lacks the professional kudos of Design with a big D. However, craft's often bemoaned but continuing association with DIY, the hobbyist, the amateur and the home, may play to its advantage in this context.'

Autochina[xxii], www.autochina.me.uk

Autochina is a website that enables users to customise designs for digitally printed surface patterns for ceramic tableware. The idea for Autochina emerged from the digital design process that Bunnell had developed for producing surface patterns herself. Working with large scale digital drawings, Bunnell's process involved using masks to select areas of a drawing and change colours from her chosen palette in order to create surface patterns for plates and mugs that were related but could be distinctly different in composition and colour. The nature of this process provided obvious opportunities for other people to intervene, making choices in relation to colour, scale and composition. At Digital Explorers II in 2007, Bunnell began a discussion with Stephen Williams of Fluidforms about the potential for an interactive interface. Through ongoing discussion, Bunnell continued to develop ideas for the quality and nature of interaction required for a possible set of online design tools and Williams wrote the software code for these tools. In addition to designing the interaction, it was necessary to think through the whole service from a user's perspective: resolving issues of payment and delivery as well as more familiar issues such as design ranges, colour and forms available for customisation. It was also necessary for Williams to write software code that would enable Bunnell to create high resolution print files from data captured online from low resolution web friendly imagery. These high resolution image files are produced as digitally printed ceramic transfers that are fired onto ceramic blanks. The web pages were created by a graphic designer using Bunnell's artwork and the whole web design and interactive aspect came together through collaboration between all three parties. As suggested by the web based businesses reviewed here, the skeleton system developed for Autochina has the potential to support remote, localised, made to order production, in this case through the use of distributed digital ceramic print bureaus. The site is very much a prototype that now requires user testing and the process of creating this prototype has already raised many questions for Bunnell about her role in the process.

The first set of questions arises from thinking about potential users: are they consumers, are they buyers for the existing retail industry, are they a community of surface pattern designers sharing ideas and developing products together? The second set is closely linked to users and revolves around how Bunnell as a surface pattern designer can continue to interact creatively with the site for example by uploading new patterns and imagery; changing colour palettes; introducing new forms for decorating; and perhaps most importantly, interacting online with people who visit the site in order to get feedback and suggestions on design development, pricing and other user requirements. Implicit in this second set of questions are further questions about Bunnell's own skills and capabilities in using and developing online design tools herself. These are questions about the autonomous nature of her practice. Currently Bunnell feels the need to understand more about web design and software code in order to regain control of the whole system and be able to work with it in the most open and creative way. The ability to control the system in her current view is key to its success as a creative tool for a professional designer-maker.

Some Conclusions

Rapid manufacturing technologies are becoming more affordable and tools that enable consumer interaction with the design processes over the internet are increasingly accessible and developing in sophistication. Through the integration of online tools and digital production technologies, innovative modes of design, production and consumption are emerging. In particular the shift from mass to

individual production is creating a new design paradigm that is arguably closer to craft than it is to design.

If the essence of Craft practice is that it involves an individual in ongoing critical dialogue with a making process and that this personal dialogue by default, results in unique objects, then it would seem that digital production tools and Web 2.0 technologies effectively mix creative and commercial opportunities that makers could take advantage of. The extent to which makers engage directly with users within these systems is likely to be closely linked to the type of work that they make and to the market they supply.

It is clear that companies such as Ponoko, FOC have future visions that relate these new systems to the environmental agenda. Within these systems there is scope to develop renewable and recyclable materials that will also offer a greater variety of aesthetic qualities than those currently on offer. In a distributed localised production system for design it's possible to imagine regional variations based on material availability, creating vernacular languages commonly associated with regional craft practices.

Specifically in the area of sustainable digital craft production**, Unto this Last**[xxiii],www.untothislast.co.uk, a furniture company set up by Olivier Geoffroy in London, is championing a new business model. Taking it's name from John Ruskin's book[xxiv], Geoffroy's business is based on the re-invention of Ruskin's Arts and Crafts workshop concept using 21st century digital production tools and information communication technologies. Their *purpose is to offer customers the convenience of the local craftsman workshop at mass-production prices. We design along a single principle; less dependence on heavy industrial processes, more use of innovative digital tools adapted to the small workshop*. Their core business is based on the creation and use of digital design data and a computer numerically controlled router to produce a range of designs that can be cut from standard size sheet materials and hand finished by crafts people employed in the workshop. Their products have been designed through skilled use and understanding of their production processes enabling the creation of designs that make best use of the functional and aesthetic capabilities of the system. With showrooms and workshops attached, in Brick Lane, East London and in Battersea in South London, Unto this Last always make to order and only deliver locally. In this model design information is held in computer systems, there is no need for storage space for actual products, there is little or no packaging required and no added retail costs: local goods for local people at prices which compete with mass produced flat pack furniture.

This model has many appealing aspects when viewed through lens of sustainable business practice. The way Unto this Last currently operates is dependent on its location in one of world's largest cities, with a large customer base literally on the doorstep. Can this business model be adapted to rural or smaller city contexts? Is it possible to set up a network of showroom/workshops that offer sustainable localised production across the UK, Europe or the World? Could Geoffroy's business model be further developed through the introduction of online interaction with users or designers? Through the example of Unto this Last, is it possible to imagine a future where crafts practitioners marry their intimate understanding of designing through making with the capabilities of digital design, production, Web 2.0 and e-commerce? If it is then, this means that right now more crafts people need to acquire digital skills. And they don't just need to acquire skills they need to make demands on technology companies in relation to the human computer interface, the development of diverse, appealing and sustainable materials that are used within RM systems, and they need to start to question and develop the kind of interaction with clients that is appropriate to developing unique products with real added value.

End Notes and weblinks

[i] Banham, R, Theory and Design in the First Machine Age, The Architectural Press, Eighth impression, 1978

[ii] For more about digital economy see the Environment and Physical Sciences Research Council's Digital Economy Programme, www.epsrc.ac.uk/ResearchFunding/Programmes/DE/default.htm (accessed 24.10.09)

[iii] web design that facilitates interactive information sharing, user-centered design and collaboration on the internet.

[iv] eg. the use of technologies such as stereo-lithography, selective laser sintering and fused deposition modelling and other such additive processes to produce final products.

[v] eg computer numerically controlled lathes, mills and laser cutters

[vi] Design your own trainers at NikeID at www.nike.com, or Miadidas at www.adidas.com, or configure a Fiat at www.fiat.co.uk (all accessed 24.10.09)

[vii] This limited on-line personalisation is being extended into more meaningful customisation systems facilitated by 3D digital laser scanning and innovation in materials technology. Adidas and Bont, a cycle shoe manufacturer, for example offer a full customisation service based on foot scanning. The logistics of creating one-off products are reflected in cost of these services with Bont's fully customised cycling shoe selling at £535. www.bont.com (accessed 24.10.09)

[viii] www.materialise.com/materialise/view/en/2555641-.MGX+Collection.html (accessed 24.10.09)

[ix] www.freedomofcreation.com (accessed 24.10.09)

[x] www.fluid-forms.com (accessed 24.10.09)

[xi] www.shapeways.com (accessed 24.10.09)

[xii] www.studioludens.com (accessed 24.10.09)

[xiii] www.n-e-r-v-o-u-s.com (accessed 24.10.09)

[xiv] www.ponoko.com (accessed 24.10.09)

[xv] www.mydeco.com (accessed 24.10.09)

[xvi] www.etsy.com (accessed 24.10.09)

[xvii] www.instructables.com (accessed 24.10.09)

[xviii] www.makezine.com (accessed 24.10.09)

[xix] www.knithappens.com (accessed 24.10.09)

[xx] www.automake.co.uk (accessed 24.10.09)

[xxi] www.futurefactories.com/ (accessed 24.10.09)

[xxii] www.autochina.me.uk (accessed 24.10.09)

[xxiii] www.untothislast.co.uk (accessed 24.10.09)

[xxiv] In his book, Unto this Last, published in 1850, Ruskin discusses his concerns about the human cost of the Industrial Revolution and advocates a return to local workshops run by craftsmen. See Ruskin, J, Unto this Last, Digiread.com, 2005 ISBN: 1-4209-2596-2 also available online at www.digireads.com