Fashion in the Digital Age
Focus area: Digital technologies

Cross-Sectoral Experiences with Mass customization
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Abstract: The household textiles market is moving quickly towards fashion products that complement apparel. This creates many issues for traditional retailers who are used to product ranges with longer life cycles. The focus of the applied research reported in this paper concerns the potential of companies to transform their approach to fashion with the aid of textile digital printing to produce mass customized products. A single case study methodology has been adopted, based on a project part-funded by the UK Department of Trade and Industry. At the outset of the research, four technical problems were identified and three marketing challenges. The technical problems were concerned with color management, reduction in the use of black, the achievement of commercial standards of performance for printed textiles, and the standardization of processing conditions for textile substrates. The nature of the technical problems will be presented, together with the solutions that have been found. The market challenges were to enable three collaborating companies to operate in "virtual" mode, to identify suitable products, and to identify viable ways of getting access to consumers. Progress has been made in each of these areas, but the major issue concerns the interface with consumers. Manufacturers do not have an infrastructure giving access to markets, nor do they have the retailing expertise. At the same time, retail organizations have systems that involve holding stock items: physical products to sell. The mass customization concept is a paradigm shift for such organizations. At the same time, consumers easily confound mass customization with "made to measure". Nevertheless, the collaborating companies have found routes for digitally printed products via high street retailers and via internet sales. Spin-off companies have been formed and jobs have been created.

1. Introduction

During the past decade, the capability to digitally print textile materials has become inseparable from the concepts of rapid prototyping, mass-customization, and the manufacture of small batches of niche products (Fralix, 2001). Digital printing technologies enable garment designers and print designers to work together in concurrent mode to reduce the lead times for creating innovative products. These same technologies enable products to be manufactured for particular consumers who select images (or provide artwork) that are to be printed on the textile substrate (Tyler, 2005). This opens the door for mass-customization in apparel or in household textiles. Whilst digital technologies have been used to produce small batches of textiles with rather conventional prints, the real opportunities come when the design potential of digital is consciously exploited. This allows the manufacture of small batches of exclusive prints that cannot be reproduced by any other printing route.

The work reported in this paper concerns the mass-customization of household textiles. This focus was partly pragmatic (in that it was closest to the expertise of the participating companies), and partly a matter of strategic choice (in that the greatest opportunities for commercial success were considered to be in this area).

Three small companies were involved in the project. The textile digital printing was undertaken by Direct Textile Imaging Ltd. This company was launched to provide a rapid prototyping service directed at retail customers. The company provided various design development services, taking images and carrying out colour separation work in anticipation of screen printing. The physical samples of digital prints were provided either for the designers to assess and approve, or to allow photo shoots of product for catalogues and other promotional material. In many cases, the customer had no requirement for a durable print, so on cost grounds, no pretreatment or post-treatment was undertaken. When a permanent print was required, the company offered a polyester substrate, as a commercial heat transfer route was available for this fiber type utilizing a local company with specialist facilities in transfer printing.

The second company was the transfer printer: John Clegg & Bros Ltd. As a small family business in a conservation area, traditional wet processing has been phased out and replaced by clean processes including transfer printing. By the time of the project, this company had gained significant expertise in the use of rotary transfer presses to print a variety of polyester fabrics.

The other member of the trio was Acton & Acton, a family business making very traditional customized bedding. A network of independent retail shops placed orders for sheets and other items of bedding with sizes and fabrics selected by consumers. The company produces to order with a short lead time. This is a form of mass-customization using traditional technologies and materials. Acton & Acton brought to the project expertise in handling small batch orders through administration, cutting, sewing and dispatch.

The vision that brought these companies together was the creation of new niche markets for small-medium volumes of printed textiles for specific customers. The interior textiles market was selected for several reasons:
1. The experience of Acton & Acton was in household textiles
2. The proven "commercial route" for digitally printed textiles was using polyester, and although many clothes are made from polyester materials, the fiber type was considered to be a better match with the interior textiles market. Experience in this market was provided by John Clegg & Bros.
3. Access to consumers is diverse in interior textiles, where there is already some appreciation of the value of customization. In apparel, however, the retailer is more dominant and there is a strong tradition of ready-to-wear products.

At the outset, the companies identified the major challenges in the project. These are addressed below.

2. Project Objectives

2.1 The "Technology" challenges

1. Colour matching. Overall, the procedures in use at the time were very similar to those for screen printing. The printer made a "best guess", and any corrections were made incrementally in consultation with the client/brand owner. The perceived next step was to create colour books for each substrate type, from which the customer could select. All these options were recognized to be time-consuming, and not very satisfactory where the printing is of photographic images or paintings.

2. Reduction in the use of black. The software system used was built around a colour book, so after the RGB coordinates were determined, the nearest match was selected by the system. Although this was OK for screen printing, it proved not to be satisfactory for digital printing of textiles. One problem was the difficulty in getting continuous grading of colour, but an even more significant problem was the way the system used black ink to deepen colors. This led to many digital prints looking muddy or pixilated.

3. Achievement of commercial performance of prints. Performance parameters such as light fastness and wash fastness must meet commercial requirements. Before the project, the applications of textile digital printing had all been for samples and photo-shoots where the performance criteria were much lower. There was a need to identify specifications for performance and manufacture that are appropriate for digitally printed textiles.

4. Standardization of processing conditions for textile substrates. Although, in principle, any substrate can be printed, the need was to identify commercial routes for printing. Not all routes were viable for meeting the quality/cost/lead time targets. The greater the requirements for preparation-for-print and post-printing treatments become, the more the distinctive advantages of textile digital printing are eroded.

2.2 The "Market" challenges

1. Companies operating in "virtual" mode. The project partners envisaged order receipt, documentation and tracking to be performed online. There was a perceived need to share work in progress information from all three companies to ensure that a high degree of flexibility and quick response is achieved.

2. Identification of suitable products. The products considered for the project had relatively high square meterage. Duvet covers were considered for their potential to reproduce unique images, and also for their potential to complete a matching set. Roller blinds and wall hangings were considered because of the opportunity to put striking images on the product. Large pictures were of particular interest because of their potential to transform the appearance of a room and because of the high value-added.

3. Identification of viable ways of getting access to consumers. The route to market was not at all clear at the outset of the project. It was planned to involve a selected group of potential customers in a workshop to outline the benefits and implications of mass customisation via digital printing. This could be a springboard for developing supply chains.

The technology and marketing challenges relate well to the three key capabilities identified by Zipkin (2001, p.82). These are: "*elicitation* (a mechanism for interacting with the customer and obtaining specific information); *process flexibility* (production technology that fabricates the product according to the information); and *logistics* (subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer)."

For each of these challenges, project tasks were identified to develop solutions.

3. **The "Technology" solutions**

3.1 Color matching

The first approach to be explored required the production of detailed color books (the color atlas approach). These were made possible by the software being used. Typically, 42 pages are printed, each representing a slice of color space. In principle, this gives 32000 colour options. The approach was to equip each company with a book for each substrate in use, allowing a standard for every possible color. Apart from the time demands, and the bulkiness of each color book, the approach proved to be a limited and partial solution. This emerged when it was realized that there was less need for solid colors, as many applications worked from graphic images with numerous colors.

During the project, more substantial answers emerged via calibrated purpose-built software. New software was acquired that enabled calibration of the whole system: linking CAD screens, printed substrates and spectrophotometer measurements. The software allowed color profiles to be set up for photographic prints. Once set up, the experience of the printer was that consistency was achieved.

3.2. Reduction in the use of black.

The color book approach allowed a visual assessment of a print, and whether it was commercial. Again, this was a partial solution. With the acquisition of the new software, it was possible to manage the way black was used in the prints.

3.3 Achievement of commercial performance of prints.

Technical requirements of the finished products were identified. The key parameters were light fastness, wash performance, abrasion resistance, rub fastness, weight and texture of the fabric, resistance to alkaline perspiration, availability and cost. In each of these areas, commercial standards are available that are relevant to interior textiles products. The following table documents where conformance with standards is a requirement.

Product	Light fastness	Wash fastness	Abrasion resistance	Rub fastness
Duvet covers	✓	✓	✓	✓
Curtains	✓	✓		
Blinds	✓			
Wall-hangings	✓			
Towels	✓	✓	✓	✓
Pet mats	✓	✓	✓	
Furnishings	✓	✓	✓	✓

A program of printing samples and testing was undertaken. Some samples achieved the standards without any further work. Others revealed the need for development work, either with the class of dyes being used, or with specific colors. The project had an advantage in dyestuff development, because Direct Textile Imaging Ltd is a beta-test site for Ciba Dyes. This meant that the results of the tests were fed back to the manufacturer. Consequently, new dyes/inks were forthcoming during the project that addressed unsatisfactory performances. Ciba's Teracil TS range was the turning point: these dyes gave more consistent performance and had improved light fastness.

3.4. Standardization of processing conditions for textile substrates.

Only one commercial route was identified at the outset of the project: sublimation printing on polyester. Other routes are technically possible and all fiber types can be dyed. Cotton, for example, needs to be prepared for print using a padding machine, and post-printing it needs dedicated finishing equipment for steaming, washing, the application of finishes and drying. This involves at least £100K investment. All this adds cost to the product and reduces the number of commercial applications.

During the course of the project, technology developments in textile digital printing were monitored and a number of company's digitally printing cotton and silk were visited. A cost model was developed to support this area of the work. By the conclusion of the project, no new technology routes for mass customization had been identified, although there were some potential avenues for continuing interest. Further discussion of these issues is in Tyler (2005).
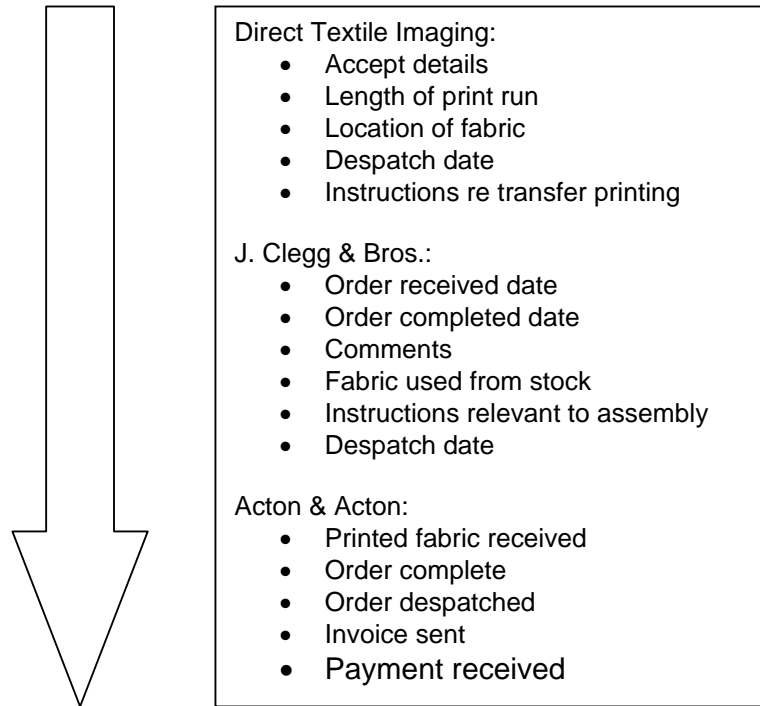

5. The "Market" for mass customized products

5.1   Companies operating in "virtual" mode.

The aim was to present a united front to customers, with access through any of the participating companies. Visibility of orders was needed, with each company being able to get relevant information for scheduling activities.

The investment needed was predominantly software, customised to the specific requirements of the project. This followed an extensive audit of requirements. The Main Menu had the following 5 categories of information:

1. Message Board. Inter-company chat, comments, memos, all dated.

2. Order Form: available for completion by any of the three companies. Boxes for date, time, product type (bed linen, pictures, blinds, etc), sizes, number of items required, fabric type, etc. There are boxes for completion by each of the three companies detailing their particular responsibilities. One of these boxes addresses the issue of copyright clearance.

3. Orders in Work. These may be accessed by all three companies. The flow chart is as follows:

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┌──────────────────────────────────────┐
│  Direct Textile Imaging:             │
│     •  Accept details                │
│     •  Length of print run           │
│     •  Location of fabric            │
│     •  Despatch date                 │
│     •  Instructions re transfer printing │
│                                      │
│  J. Clegg & Bros.:                   │
│     •  Order received date           │
│     •  Order completed date          │
│     •  Comments                      │
│     •  Fabric used from stock        │
│     •  Instructions relevant to assembly │
│     •  Despatch date                 │
│                                      │
│  Acton & Acton:                      │
│     •  Printed fabric received       │
│     •  Order complete                │
│     •  Order despatched              │
│     •  Invoice sent                  │
│     •  Payment received              │
└──────────────────────────────────────┘
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Flow chart to show how the three companies integrate their activities

4. Compiled Orders
5. Libraries: fabric types & prices, designs, graphics and photographs.
The Compiled Orders and the Libraries are essentially archived data and resources that can be accessed at any time.

Whilst the project partners did not make any claims about the originality of this approach from the perspective of information technology, it was considered to be a major step forward. This is because, two had very little experience of email and intranet applications prior to the project.

5.2   Identification of suitable products.

At the outset, the project partners were full of ideas for customized and mass-customized products. One of the advantages of the project, which was part-funded by the UK Department of Trade and Industry, was that funding was available for sampling work. So, numerous products were made on a speculative basis, to explore the limits of the technologies and to show to prospective customers. Some of these samples led to sales of commercial products, but continuity of demand and access to consumers emerged as the biggest hurdle for the project team.

In several cases, it became apparent that what consumers wanted was a customized product, not a mass customized product. Also, having the ability to put any image onto a textile substrate has been found to be so open-ended that consumers fail to make any decision. This is the danger of giving too much choice to consumers, as highlighted by Huffman and Kahn (1998). Learning from these experiences has been part of the project. It has led to the project team seeking out artists with whom they can collaborate to place specific images before

consumers. Further initiatives to identify ways of developing product modularity, as discussed by Duray (2002) are under way.

5.3   Identification of viable ways of getting access to consumers.

The reactions of retailers were consistent during the project. These companies wanted product to put before customers and had no infrastructure to handle mass-customization. The emphasis always was on price, with comparisons made with imported stock items. Few saw the advantages of offering consumers a customized service. However, a beginning has been made, with one retailer offering customized products first on its web site, and exploring ways of offering this to consumers in the stores.

A major effort was given to impacting companies selling direct to consumers. These included companies supplying blinds, architects and interior decorators. Although interest was high, there were very few organizations taking things further. Some of the business coming to the group via this route was not mass-customization at all, but bringing unique digital prints into the range of off-the-shelf products on offer.

Direct Textile Imaging launched a web site to promote these products. The URL is: http://www.modern-imagesuk.com/
This has been a learning experience for the company, because selling direct via the web requires a variety of skills not normally found in companies that have hitherto focused on business customers. This activity is ongoing.

As a summary, the major product categories that have been explored are listed below, with some general comments on market penetration.
   (a) Bedding with special prints (Experience is that volumes are small: this is a price-sensitive market for most consumers).
   (b) Wall coverings, cushions and bags. (There are currently dozens of sponsored sites on Google selling digital pictures and wall hangings. Most offer a 14-21 day delivery. A figure of £70m per year has been estimated for this business by one analyst. This is a major growth area involving internet interfaces between producer and consumer. So far, few major retailers have made much of a response.
   One which has is Mothercare, where in some stores, consumers can go into the store and sit down in front of a CAD screen and buy products. The website offers a weekend bag for £70, a 30 x 30 picture canvas for £60, purse for £25, wash bag for £30 and cushion for £30 (small) or £40 (large).
   John Lewis Partnership offers a 40 x 40 canvas print for £60 and a 60 x 40 print for £75.)
   Modern-images.com was set up to capture some of this market.
   (c) Blinds. Attempts to introduce mass-customisation here have not met with success. However, some national blind manufacturers have adopted digital technologies because of the design potential (urban scenes, etc). These are offered as stock items.

6. Conclusions

The methodology adopted for this research has been the single case study. This has allowed the identification and analysis of real barriers to the implementation of mass customized products in the context of interior textiles.

The technical challenges have proved easier to address than the marketing challenges. The technical issues are not trivial, and they are rarely solved in isolation. Innovations in software, in dyes/inks, in equipment technology, and so on, all contribute to achieving commercial products. This assessment is not new. Since the early 1990s, the potential of textile digital printing has been recognized, but it has needed the concerted efforts of many players to turn potential into reality.

Existing channels for reaching consumers (High Street and independent retailers) have not embraced the mass-customization concept. Experimentation has taken place, but stock items predominate. This is a major issue to address for any who think mass-customization to be the way for retail to develop (particularly if mass-customized clothing is to become viable).

New avenues are rapidly emerging via the Internet, although having a web site is just getting a foot in the door. Internet marketing is a major challenge in its own right. It is possible to set up a site and not attract business. Skills of internet marketing and internet retailing are urgently needed for this route to become significant for manufacturers to reach consumers with their products.

It is possible for niche businesses utilizing specialist technologies to successfully provide mass customization products. It can be argued that small businesses are best suited to experiment and to lead change. However, many new skills are needed, particularly in marketing, brand management and accessing consumers. This is consistent with one of the conclusions of Da Silveira *et al* (2001) that "to implement mass customization it is necessary to integrate different manufacturing technologies into a structured framework capable of combining human and technological factors".

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