REFERENCES

BIS (2013) Research Paper No.146 'The Benefits of Higher Education Participation for Individuals and Society: key findings and reports "The Quadrants". [Internet] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/254101/bis-13-1268-benefits-of-higher-education-participation-the-quadrants.pdf [Accessed 03/08/15]

Brown, T. (2008) Design thinking. *Harvard Business Review*. 86 (6): 84.

Brown, T. & Katz, B. (2009) **Change by design: how design thinking transforms organizations and inspires innovation**. New York: Harper Business.

Buchanan, R. (1992) Wicked Problems in Design Thinking. *Design Issues*, 8 (2): 5-21.

Coghlan, D. & Brannick, T. (2014) **Doing action research in your own organization** (4th ed.). London: Sage.

Cross, N. (2001) Designerly Ways of Knowing: Design Discipline versus Design Science. *Design Issues*, 17 (3): 49-55.

d.school Standford University (2015) *Welcome to the virtual crash course in design thinking*. [Internet] https://dschool.stanford.edu/dgift/ [Accessed 03/08/15].

d.school Standford University (2010) **bootcamp bootleg**. [Internet] http://dschool.stanford.edu/wp-content/uploads/2011/03/BootcampBootleg2010v2SLIM.pdf [Accessed 03/08/15].

de Corte, E. (2010) Historical developments in the understanding of learning. In H. Dumont, D. Istance & F. Benavides (Eds.) *The Nature of Learning: Using Research to Inspire Practice*, 35-67. Paris: OECD Publishing.

Dewey, J. (1916). **Democracy and education**. New York: Macmillan.

Downing, K., Ho, R., Shin, K., Vrijmoed, L. & Wong, E. (2007) Metacognitive development and moving away. *Educational Studies*, 33 (1): 1-13.

Downing, K., Kwong, T., Chan, S., Lam, T. and Downing, W., (2009). Problem-based learning and the development of metacognition. *Higher Education*, 57 (5), 609-621.

Drews, C. (2009) Unleashing the Full Potential of Design Thinking as a Business Method. *Design Management Review*, 20 (3): 38.

Driscoll, M. P. (1994). **Psychology of learning for instruction**. In Downing, K., Ho, R., Shin, K., Vrijmoed, L. & Wong, E. (2007) Metacognitive development and moving away. *Educational Studies*, 33 (1): 1-13.

Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D. & Leifer, L.J. (2005) Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education*, 94 (1): 103.

IDEO (2011) *Design Thinking for Educators Toolkit*. [Internet] http://www.ideo.com/work/toolkit-for-educators [Accessed 03/08/15].

Johansson-Sköldberg, U., Woodilla, J., Çetinkaya, M., (2013) Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management*, 22 (2): 121-146.

Kelley T. (2001) **The Art of Innovation**. New York: Harper Collins Business.

Kelley, T., Littman, J. & IDEO (Firm) (2006) **The ten faces of innovation: IDEO's strategies for beating the devil's advocate & driving creativity through your organization.** London: Profile Books Ltd.

Lawson, B. (1997) **How designers think: the design process demystified** (3rd ed). Oxford: Architectural Press.

Levin, M. (2003) Action research and the research community, in Coghlan, D. & Brannick, T. (2014) **Doing action research in your own organization** (4th ed.). London: Sage.

Liedtka, J. & Ogilvie, T. (2011) **Designing for growth: a design thinking tool kit for manager.** New York: Columbia University Press.

McWilliam, E. (2009) Teaching for creativity: from sage to guide to meddler. *Asia Pacific Journal of Education*, 29 (3), 281-293.

Martin, R. L. (2009) **The design of business: why design thinking is the next competitive advantage**. Boston: Harvard Business.

Melles, G. & Misic, V. (2011) Introducing Design Thinking to Undergraduate Design Students at Swinburne University: Expanding Horizons. *Special Issue of Japanese Society for the Science of Design*, 18-1 (69).

Melles, G., Anderson, N., Barrett, T., & Thompson-Whiteside, S. (2015) Problem Finding through Design Thinking in Education. *Inquiry-Based Learning for Multidisciplinary Programs: A Conceptual and Practical Resource for Educators (Innovations in Higher Education Teaching and Learning, Volume 3) Emerald Group Publishing Limited*, 3: 191-209.

Orna, E. & Stevens, G. (2009) **Managing information for research: practical help in researching, writing and designing dissertations** (2nd ed). Maidenhead: McGraw-Hill Open University Press.

Piaget, J. (1952) **The origins of intelligence in children.** New York, NY: International University Press.

Rogoff, B. (1990) **Apprenticeship in thinking: cognitive development in social context.** New York: Oxford University Press.

Rowe, P. G. (1987) **Design thinking.** Cambridge: The MIT Press.

Simon, H. (1996) **The sciences of the artificial** (3rd ed). Cambridge: The MIT Press.

FIGURE CAPTIONS AND CREDITS

Figure 1: Design Thinking Process – adapted from d.school Stanford University Institute for Design.

Figure 2: Storytell.

Figure 3: Brainstorm.

Figure 4: Voting.

Figure 5: Feedback & Capture.

Figure 6: Feedback & Capture.

Figure 7: Number of respondents who found the techniques helpful or very helpful by assignment.

ANNE MARR AND REBECCA HOYES
CENTRAL SAINT MARTINS

MATERIAL BOUNDARIES

CO-DESIGN | OPEN-ENDED RESEARCH | HYBRID MATERIALS
PROCESS-LED TEXTILE RESEARCH | TEXTILE THINKING

ABSTRACT

THIS PAPER PORTRAYS THE JOURNEY OF A COLLABORATIVE RESEARCH PROJECT BETWEEN THE AUTHORS REBECCA HOYES AND ANNE MARR, BOTH EDUCATORS AND RESEARCHERS ON THE BA (HONS) TEXTILE DESIGN AT CENTRAL SAINT MARTINS (CSM).

The project started as an open-ended research investigation exploring existing material boundaries in the hope to develop new hybrid ceramic – textile materials. *The Material Boundaries* project was designed to explore first steps into these new territories, to consciously experiment beyond the unknown, generate a deeper understanding of future craft processes and open up further opportunities for co-design with other disciplines. The paper outlines an investigation into where ceramic begins and textiles end and the transitional space in between them. The findings of this paper identify risk-taking and co-design as essential strategies to invite valuable setbacks and disasters, as well as happy accidents. The key stages of an open-ended research process are outlined: Mapping New Terrain, Material Investigation, Trans-disciplinary Feedback and Systematic Reflection. The project took risk-taking to the extreme by firing material hybrids in a kiln, often 'producing' not even a trace of dust. This paper presents a visual journey of the reflective mapping process, illustrating the key stages of the research. Transdisciplinary feedback from colleagues supported the progression of the project applying ceramic and textile thinking to the journey.

For full-time educators, time to develop new research is often very limited, which makes it challenging to develop deeper knowledge and risk open-ended new research questions, as tweaking existing techniques guarantees a 'successful' research question to outcome in a short span of time. At the same time textile design has rapidly expanded into a more interdisciplinary practice and educators need to keep abreast of these new directions to be able to teach their students valuable future skills. In particular, the broadening of disciplines in which the methods and concepts of textile design are taken as catalysts and vehicles for new collaborative ways of making. This paper suggests methods and processes to invite more risk-taking into textile research curricula and investigates how tacit knowledge about materials can be integrated and communicated within the framework of research.

INTRODUCTION

This paper portrays the journey of a collaborative research project between the authors. At the core of this exploration is engaging with *process* rather than set end results and in fact the process of the project is its outcome. Therefore, this paper focuses on the process of learning through investigation and on the nature of collaboration. The project started in Summer 2014 through a mutual interest in process-led research as well as ceramics and is on-going until Spring 2016. The aim of *Material Boundaries* is to develop new textile/ceramic hybrid materials (figure 1) and to explore the possibilities of co-design as well as to record process-led textile design methods in order to inform research and teaching practice.

CONTEXT: WHERE DO TEXTILES END AND WHEN DO CERAMICS BEGIN?

HYBRID MATERIALS

In 2014 CSM organised a graduate exhibition *Restless Futures*, which raised debate and posed questions around emerging issues in design. *Expanded Boundaries* was one of the four themes of the exhibition and the *Material Boundaries* project was partly born from reflection on the exhibition manifesto which predicts, that methods and concepts of design will be 'taken into other areas as catalysts and vehicles for new collaborative ways of thinking and acting.' (Restless Futures 2014)

Over the past few years, textiles have rapidly expanded into an interdisciplinary practice. Here the broadening of disciplines allows for textile design and textile thinking to be used for new collaborative ways of making. These merging and

1

2

uncertain boundaries create a space for innovative opportunities: 'More notably it is in the cross fertilisation of materials where a new breed of designers are evolving. Materiologists are those designers who are happy to cross boundaries, explore the unexplored and are driven by materiality' (Wagner 2014: unknown).

New materials are getting increasingly 'smarter' and adaptable with great potential to inform future lives. At the same time it is no coincidence that the interest in raw haptic materiality has surged in a world increasingly shaped by enhanced digital technologies. Re-establishing an intrinsic relationship between material, maker and user has seen a desire for connectedness emerging which has '...driven the way for new interpretations of Materiality, as opposed to merely applying materials as an afterthought' (Lefteri 2014: unknown). Textiles and ceramics both have, as part of their cultural DNA, some of the most raw, low tech physical origins for example, silted earth dug up from riverbeds or sheared sheep skin (Miodownik 2013). Through chemical processes they can evolve respectively into the most sophisticated porcelain or high tech woven Tweed fabric. 'Disseminating information extensively and beyond the scope of the obvious applications is a precondition for discovering new applications. Such dissemination requires a new approach on the part of manufacturers and designers' (Material World 2 2006: 23). Whilst manufacturers take on this new approach and experiment with yarns and clay to solve specific design and production problems, the authors began from a position of curiosity: using the making process as a way of thinking through material to create new material hybrids. It is this liminal space between textiles and ceramics and where these two disciplines come together that is the focus of this project.

CO-DESIGNING UNCERTAINTY

At the same time the project also takes on a further dimension as a collaborative investigation between the authors in their roles as a BA Course Leader and academic researcher and as an Associate Lecturer and professional design practitioner. Although they share a mutual openness to experiment and have taught students together for a number of years, they have not previously co-researched or collaborated on a project. Sanders and Stappers (2008) comment on the value of the co-design process as an opportunity to engage in moments of decision and idea generation. The significant value of using co-design at the start of the design process, as a method to break down traditional roles of subject and research has been described by Shumack (2015).

Learning from mistakes is defined as a key factor in the design journey (Petroski 2006). The opportunity offered by a project, which inserts notions of 'risk', 'uncertainty' and 'failure' into the outcomes is an interesting one. At the outset of the project the authors were not so concerned with the design application as they were to initiate playful experiments into where Textiles end and ceramics begin, whilst using textile thinking as a cross-disciplinary lens on the utilisation of ceramic qualities and processes. Therefore, the initial research question: 'Where do textiles end and when do ceramics begin?' was left deliberately open to develop a deeper material understanding through process-led research. Noting that a design project that is 'too planned' (Osmond et al. 2008: 250) does not challenge existing design clichés, while a research enquiry without any inbuilt systematic reflection lacks rigour and direction (Bolton 2015: 279). Although experts in their fields of textile design, neither author had previous experience of ceramic design. Using their lack of predetermined ceramic knowledge to their advantage this exploration started as a playful challenge to see how textile materials would endure extreme temperatures required in the firing of ceramics.

Textile design is constantly expanding into a more interdisciplinary practice and educators need to keep abreast if they want to teach their students emerging skills. For full-time art and design educators, time to develop new research is often limited, which makes it challenging to maintain and develop deeper subject knowledge in order to evolve an optimal curriculum. 'The most useful learning in the modern world is learning about the process of learning, an internalisation of the experience of change' (Brockbank & McGill 2007: 209). The authors set themselves the task of doing what they expect their students to do during their studies: to go into unfamiliar territory with a curious mind, understanding risk-taking and collaborative working.

PROJECT DESCRIPTION AND TIME LINE

PHASE 1 – INTRODUCTION TO MATERIALS AND PROCESSES

The starting point was the enthusiasm to experiment and explore an open-ended research outcome together. With minimal knowledge of ceramic processes the main aim was to see how textile materials would transform under high temperature and fuse to create unexpected outcomes, compared with the relatively immediate and controllable process of textile making. This led to research into fire-resistant textile materials and a cautious start testing silica material strips and their bonding qualities with porcelain slip (figure 2).

3

Clay becomes a ceramic when it has been fired above 573°C, a process known as Alpha Beta Quartz Inversion. However, most textiles cease to exist at 100°C and even 'flameproof' materials seldom withstand the ten hour-long firing in the kiln. Using a number of small test samples and three different temperature settings between 600°C and 1200°C the first round of tests resulted in findings that the porcelain slip did not adhere easily to the textiles and at the same time the silica fabric could hardly tolerate temperatures above 600°C. Often the test firing produced nothing but 'coptic' dust fragments (figure 3). During this phase the informal short technical inductions from the ceramic technicians became vital to build up basic knowledge and progress the project.

PHASE 2 – QUANTITATIVE LATERAL TESTING

The first review of the surviving test strips identified the need to expand the material selection to include high tech textiles that could withstand temperatures above 600°C and stimulate new fusion recipes. It also revealed that more fibrous clay, such as paper clay, could enhance the cohesion between textiles and ceramics and develop a better amalgamation of the two materials. The open-ended nature of the project made it difficult to set boundaries due to the infinite possibilities of our research direction. Existing textile knowledge helped to structure phase two more systematically according to known textile properties such as material and construction processes, which were systematically combined:

Fibre and Material: basalt, kiln-fusing fleece, Kevlar, silica, resin coated polyester, Kynol, glass fibre, Kerafol

Process: rope making, knotting, weaving, pleating, twisting, stitching, mark making, screen printing, laser etching, laser cutting, glueing, dipping, flocking

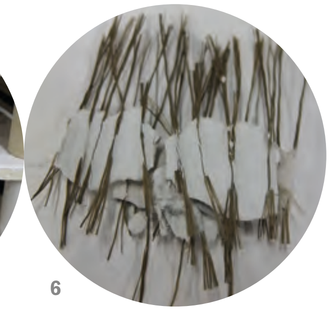
Ceramic Material: porcelain slip, paper clay, paper clay slip, Endecca Once Fired slip

This framework gave scope to explore larger quantities of lateral experiments as opposed to a small number of in depth technical tests, without getting lost in too many possibilities. Over 80 test samples were produced in phase 2 (shown in figures 5, 6, 7, 8), compared with 24 samples in phase 1.

MATERIAL:	BASALT	FLEECE	KEVLAR	SILICA	POLYESTER	KYNOL	GLASSFIBRE	KERAFOL
PLEATING	X	X		X		X		
LASER-CUTTING	X	X		X				X
LASER-ETCHING		X	X	X				
PRINTING	X	X	X	X			X	X
KNOTTING				X			X	
STITCHING	X		X	X				
DIPPING	X	X	X	X	X			X
GLUEING	X	X	X		X			X
KYMOL FLOCKING		X	X	X		X		X

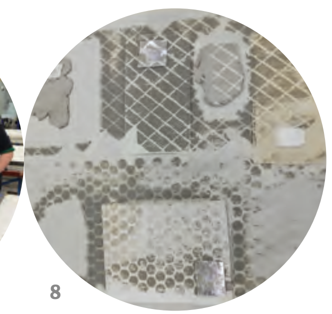
4

5

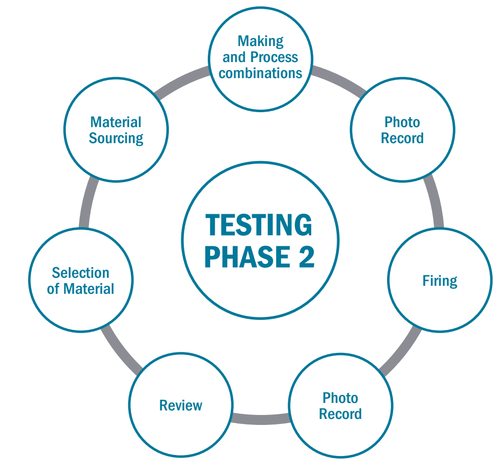


6

7



8



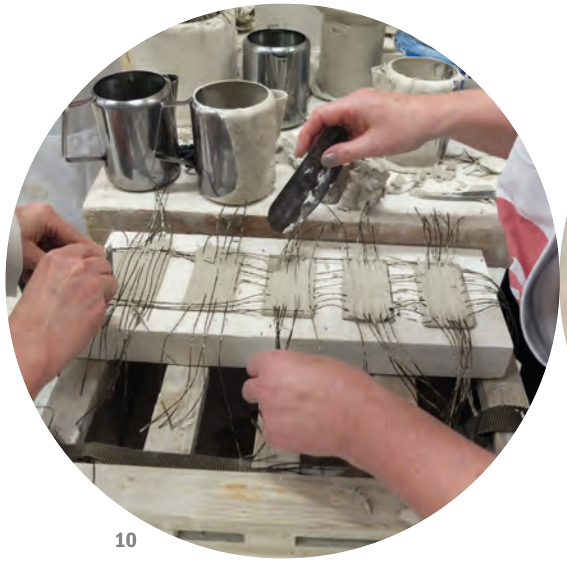
9

PHASE 3 – REVIEW

As the project evolved it became apparent that photography would be a key editing tool to manage the emerging research strands of the project. The fragile nature of the work meant that photographic records of all processes and results before and after firing became invaluable. This led to a continuous cycle of photographic documentation, followed by systematic reflective review after each workshop session (figure 9) in order to select materials and techniques to progress to phase 3 of the project.

At this point a first crit with a senior lecturer from BA (Hons) Ceramic Design was arranged to obtain additional professional feedback on the phase 2 test samples. This proved to be invaluable in obtaining further knowledge of ceramic terminology and at the same time, there was an immediate mutual understanding of the possibilities presented by process-led design research. The discussion identified different 'life expectancies' of materials and questions around sustainable ceramic making processes as well as the value of short-life outcomes. The review recognised phase 2 research as a valid method for exploring chemical reactions, the ceramics lecturer commented: 'Testing of different clay types with unknown surface treatments: this is what ceramic research is all about!'. However, it also emerged that until this point three-dimensional (3D) shapes had not been considered in the investigation and to do so could add further ceramic potential to the project. The review resulted in a selection of three sustainable key materials that generated the most natural fusion of clay and textiles after a firing process of 600°C, while preserving the haptic qualities of being simultaneously hard and soft: basalt, silica as well as once fired clay.

DURING THIS PROJECT THE AUTHORS DELIBERATELY DID NOT SET THEMSELVES A USER-CENTRED DESIGN PROBLEM BUT INSTEAD EMBARKED ON A JOURNEY OF 'MATERIAL FICTION' – IMAGINING A POTENTIAL CHEMICAL REACTION BETWEEN FABRIC AND CLAY, THROUGH PROCESS-LED DESIGN RESEARCH.


10


11

PHASE 4 – PARTICIPATORY WORKSHOP

Six months into the project the authors recognised their limited expertise in constructed textile techniques and brought in other textile experts to evolve ideas and skills. The authors decided to build in a knowledge exchange workshop to enable all participants to learn something, while at the same time gathering feedback on the project. Key to this was the idea of co-learning how to use slip casting as a method to explore 3D textile hybrid forms. Putting all participants in the same position, exploring a new technique without any prior knowledge or existing hierarchies. Ten colleagues from two different colleges participated in the workshop: full-time and fractional academic staff, PhD students, technicians, associate lecturers and research assistants. The workshop day included a 'Show and Tell' session of existing findings and material properties, a crash course in the history of ceramics, as well as a demonstration of slip casting. After which participants were completely free to use any of the materials provided with any textile technique, as long as this was used in combination with clay or slip casting. The session ended in a mini presentation of all participants' products and direct feedback. Overall, each participant produced an average of three slip cast pieces as well as contributing to a large shared outcome (figure 10).

The feedback was extremely positive with all participants saying they had found the workshop useful for their own research as well as learning a new technique. This led to the development of new 3D elements made of yarn construction in combination with slip casting, which will inform design development in phase 6 (figure 11). The project is currently on going with phase 5, which involves glazing processes and colour application to lead to selective design developments in phase 6. However, for this paper the authors have focussed on the description and analysis of the research process rather than the final design outcomes.

DISCUSSION

The nature of this project brought together different strands of research, which relate to the complex educational, academic and professional design context in which the authors are operating. Therefore, the following discussion aims to map a holistic overview of key findings and their interrelationship with each other:

- Making Material Knowledge
- Co-designing through Unlearning
- Out of Boundary

MAKING MATERIAL KNOWLEDGE

The hands-on and open-ended nature of this project enabled the discovery of new material knowledge through a lateral and immediate approach to making. Gaining an insight into a particular practice from within the practice itself followed Heidegger's (1962, 2010) notions of 'handling' and 'handlability'. Carter's (2004) conception of 'material thinking' offers a view on active materials in creative processes. According to him, materials are neither passive nor instruments, but interact with the maker's artistic intelligence when hands, mind, and eyes are connected in a creative process (Carter 2004) (figure 12). Tacit knowledge expands through direct material manipulation, providing a deeper hands-on understanding of design practice itself.

Dewey (1925) considered experience and action as knowledge, which could be summarized, possibly in the axiom, doing is knowing. The very act of making is both the process and the subject: The materialization of an object i.e., craft making, can be considered the '...subject-matter and sustainer of conscious activity' (Dewey 1925: 393). During this project the authors deliberately did not set themselves a user-centred design problem but instead embarked on a journey of 'Material Fiction' – imagining a potential chemical reaction between fabric and clay, through process-led design research. This resonates with Sanders and Stappers' (2014: 6) recent descriptions of the changing role of making in the design process, where '...making activities are used as vehicles for collectively (i.e. designers and co-designers together) exploring, expressing and testing hypotheses about future ways of living.'. They describe probes, prototypes and toolkits as three approaches to making and define their positioning within the phases of the design process (Sanders & Stappers 2014). Arguably this framework is based in a product design context, as the positioning of a probe or prototype would have to be included in the first phase of process-led textile design research. While Sanders and Stappers (2014) base their framework on 'designing for' and 'designing with' the authors of this paper have observed open-ended material research very much based on 'designing through' and 'designing with'. Here a 'process scenario' leads to speculative material qualities before user-led design research begins.

Brassett (2011: 7) states that 'Design is an activity which should always seek to create value whilst recognising and participating in the socio-cultural context in which it operates...'. This paper argues that successful material thinking can inform designers prior to the formulation of a socio-cultural driven design problem, as new materials might offer possibilities that design thinking without material handling might not have brought about. It is this '...intuition of the unthought known' that Gormley describes (2007: 118) and where much of the magic of innovation lies.


12

13

14

The collaborative nature of the project ensured that multiple reflective viewpoints informed the research and ongoing iterations of experiments. Reid (1993: 305) defines reflection as '…a process of reviewing an experience or practice in order to describe, analyse, evaluate and also to inform learning about practice'. Having expertise as textile practitioners the authors were able to use textile thinking to work with selected materials and adopt the role of a 'reflective practitioner' (Schön 1983) to scrutinize and reflect on the making processes and resulting works. In addition, 'reflection-in-action' suggests a process by which a practitioner encounters an unfamiliar situation that requires a different course of action from that which he or she typically does or has initially planned (Schön 1983).

During this project a number of unfamiliar situations occurred, such as material bonding qualities or unknown firing processes, shrinkage and colour changes which required continuous reflection in action. Additionally, careful planning of experiments and testing ensured that the authors were able to build upon acquired reflective material knowledge and managed to surprise the ceramics team with new techniques, such as glazing directly onto unfired silica fabric. 'Intentional, methodical creative productions can test a variety of ideas in practice and openly demonstrate the researcher's way of improving his or her professional practice, i.e. what and why an action takes place in a creative process, and the result of it' (Scrivener & Chapman 2004: 4).

Photographic documentation was used as a systematic reflection tool to record the resulting test pieces throughout the project (figure 13) as well as to establish key outcomes in phase 5. Bolton (2015: 279) describes the systematic reflection approach as '…the capacity to reflect on actions as a means of engaging in a continuous process of learning, with systematic approaches to analysis and synthesis' to achieve deep holistic thinking. Experiments at all phases of the process were photographed and served as an invaluable catalogue of developments, especially as some of the outcomes were fragile ceramic dust. The records underpinned visual editing methods to progress the project and to recognise patterns in material qualities as well as opportunities for development, acknowledging issues and less innovative outcomes. Formalizing the project journey through photographic documentation and the development of a photographic journal facilitated a more objective distancing from the creative/making process.

CO-DESIGNING THROUGH *UN*LEARNING

Both authors had experience of collaborative projects and were aware of the points at which difficulties can arise. The authors naturally assumed certain practical roles, which allowed for greater productivity in the different stages of the project such as material sourcing, bid writing or liaising across college departments.

Design processes that involve teamwork are social processes (Cross & Cross 1996) and require trust in the integrity of the project partner to embrace uncertainty during an unknown making process and abilities to steer through inevitable failures. Any collaboration is a matter of risk-taking, where one's approach and position may be reinforced, extended or changed in unexpected ways. Elements of mutuality and equally, indifference, have to be negotiated constantly. Continuous dialogue was key to the progress of this collaboration: dialogue between ourselves, with colleagues and with materials.

Other factors that contributed to an effective non-hierarchical collaboration were negotiations around the ownership and authorship of the project. In phase 1 equal ownership and encouragement to bring all relevant and differing skills to the project were evident. This 'lack of ownership' meant that the authors were able to be less precious and let go of their individual identities as designers and ultimately to take greater risks. Co-designing meant sharing knowledge, skills, time, resources and pushing the project into directions that might not have been conceived alone. This was particularly valuable for the initial generative stages of the co-design process, in phases 1 and 2, as the authors could consciously create an open space to learn from each other and go beyond individually established design methods (Sanders & Stappers 2014).

The idea of co-designing was extended by inviting colleagues from different textile specialist areas to a participatory workshop (figure 14). Part of the motivation behind this was to evoke a focused discussion around the display of phase 2 material samples as '…the phenomenon is on the table…' (Sanders & Stappers 2014: 6). The workshop also offered the opportunity to actively co-learn a new process:

CROSS-COLLABORATION BETWEEN DISCIPLINES OFFERS THE OPPORTUNITY TO DISCOVER UNKNOWN LIMINAL SPACE AND NEW DOMAINS OF 'COLLECTIVE CREATIVITY'.

15

slip casting. This put everybody on the same 'amateur' level and created a non-hierarchical environment in which all participants were equal experts. Bergold and Thomas (2012) describe the creation of a 'safe space' as key to facilitating openness in participatory design workshops, also described by Morrison and Marr (2013). Each of the participants brought with them prior textile knowledge and they were quickly able to assimilate new information that related to the workshop. The distinctive tacit knowledge brought to the group became more evident once the materials had been combined with the cast. In hindsight, the workshop became a key threshold in this project, as the diverse responses provided a new direction for the next stage. The participants themselves also gave positive feedback and stated that they had gained new research insights and particularly enjoyed meeting colleagues from other programmes.

OUT OF BOUNDARY

There were some very immediate results of this cross-disciplinary project, which were linked to the physical space and the building. Working in the ceramics department led organically to a new familiarity with the different approaches technicians and staff there might have. Indeed, working in a college as large as CSM there is a danger that one is identified as 'belonging to' a particular area and a colleague noted that the authors looked 'a bit out of boundary' in a different workshop context.

Even though the authors had a great deal of shared textile knowledge an important outcome of this project was to 'un-learn' this knowledge: putting aside existing textile assumptions and preoccupation to go beyond binding parameters. The cross-fertilisation of materials, in combination with a variety of processes and concepts provided numerous opportunities for unlearning. For example, the authors deliberately worked with yarns which displayed unsuitable haptic textile qualities before the firing process, as they discovered that the yarn quality would transform after the exposure to the kiln. The transformation process through firing meant that all material qualities were constantly adrift and often at risk of complete loss. The scale of transformation and the danger inherent in the lack of control of the ceramics process felt daring in comparison to textile processes, where material qualities can gradually be developed, altered and restored. In that sense, the majority of ceramics thinking has the complete transformation of clay particles at its core. Fundamentally, this aims to produce a sense of permanency, while traditional textile thinking takes the physical structure of a material for granted, in addition to which, this can be seasonal. This unlearning was a necessary part of the project, ignoring set rules of textile practice and applying textile thinking to unfamiliar materials and processes to invite creative risk-taking, happy accidents and often improvisation. Uncertainty, more often than not, led to a shift in direction and the development of a new axis of thought. Embracing 'uncertainty' has definitely been a key threshold in progression of the project. Mcdonnell (2012) states that a designer must be in possession of Keats's Negative Capability (Gittings & Mee 2002) for example, the ability to be at ease with working in a state of partial knowledge, to be at ease with uncertainties and contradictions.

CONCLUSION

HANDLING FLUID COMPLEXITY

This paper has revealed the value of process-led design research with no predetermined outcomes and of learning through non-hierarchical collaborative making (figure 15). Through the above findings the intricacy of inter-disciplinary research has become evident and this new creative complexity brings uncertainties and opportunities to the design process. Cross-collaboration between disciplines offers the opportunity to discover unknown liminal space and new domains of 'collective creativity' (Sanders & Stappers 2008: 16).

Materials frontiers provide invaluable design impulses for researchers, designers, educators and students alike. However, in order to positively navigate future projects without getting lost in the infinite outcomes the authors make the following recommendations:

- Treat materials as an active source of design information and invite the making of tacit knowledge through direct material handling;
- Structure process-led design research through systematic reflective photographic documentation;
- Understand collaboration as a social process and establish non-hierarchical environments to nurture collective creativity;
- Invite unlearning as a deliberate part of process-led design research.

Finally, these findings reveal the value of textile thinking and its particular approach to understanding and developing ideas, processes and qualities, as well as outcomes. The amalgamation of this knowledge with other disciplines is an exciting future prospect.

ACKNOWLEDGEMENTS

This paper was conceived while the authors were respectively a Course Director and an Associate Lecturer on BA (Hons) Textile Design at CSM, University of the Arts London.

The *Hybrid Materials* project was only possible with funding support from CSM as well as the Textile Future Research Centre, University of the Arts London. We would also like to thank Andy Allum, Natsai Chieza, Peter Close, Carole Collet, Simeon Featherstone and Duncan Hooson in particular for their invaluable enthusiasm, inspiration and support.

REFERENCES

Bergold, J. & Thomas, S. (2012). Partizipative Forschungsmethoden: Ein methodischer Ansatz in Bewegung. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 13(1), Art. 30. [Internet] http://nbn-resolving.de/urn:nbn:de:0114-fqs1201302 [30/07/15].

Bolton, S. (2015) The Visual Thinking Method. In P. Rodgers and J. Yee (eds) *The Routledge Companion to Design Research*, 277-291. Oxon: Routledge.

Brassett, J. (2011) The uncertainty project: managing uncertainty in innovation education. In: *Cumulus 2011, Crossing Talents: Transversaility in Design*, 19-21 May 2011, Straté College, Paris. (Unpublished).

Brockbank, A & McGill, I (2007) **Facilitating Reflective Learning in Higher Education** (2nd ed.) Buckingham: SRHE and the Open University Press.

Carter, P. (2004) **Material Thinking: The theory and Practice of Creative Research. Carlton.** Victoria: Melbourne University Publishing.

Cross, N. & Cross, A. (1996) **Observations of Teamwork and Social Processes in Design**. Oxon: Routledge.

Dewey, J. (1925). **Experience and nature**. New York: Kessinger.

Gittings, R. & Mee, J. (eds) (2002) **John Keats Selective Letters**. Oxford: University Press.

Gormley, A. (2007) Thinking about Naoto Fukusawa. In F. Naoto (ed) *Naoto Fukusawa.* London: Phaidon.

Heidegger, M. (1962, 2010) The Origin of the Work of Art. In C. Taylor, *Basic Writings: Martin Heidegger*. Oxon: Routledge.

Lee, J. (2014) **Material Alchemy**. Amsterdam: BIS Publishers.

Lefteri, C. (2014) **Materials for Design**. London: Laurence King.

Material World 2 (2006) **Material World 2 Innovative Materials for Architecture and Design**. Basel: Birkhauser – MateriO.

Mcdonnell, J. (2012) Accommodating disagreement: A study of effective design collaboration. *Design Studies*, 33 (1): 44-63.

Miodownik, M. (2013) **Stuff Matters**. London: Penguin.

Morrison, J. & Marr, A. (2013) Threads and Yarns: Intergenerational Engagement and Cross-Disciplinary Research Through Textiles. *Journal of Textile Design Research and Practice*, 1 (1): 57-76. London: Bloomsbury.

Osmond, J., Turner, A. & Land, R. (2008) Threshold Concepts and Spatial awareness in Transport and Product Design. In R. Land, J. Meyer and J. Smith (eds), *Threshold Concepts in the Disciplines*, 243–258. Rotterdam: Sense Publishers.

Petroski, H. (2006) **Design through Failure**. Princetown: University Press.

Reid, B (1993) "But we're doing it already" Exploring a response to the concept of reflective practice in order to improve its facilitation. *Nurse Ed Today 13*.

Restless Futures (2014) **Website**. [Internet] www.arts.ac.uk/csm/csm-culture/restless-futures [Accessed 16/04/16].

Sanders, E. & Stappers, P. (2014) Probes, toolkits and prototypes: three approaches to making in codesigning. *CoDesign: International Journal of CoCreation and the Arts*, 10 (1): 5-14.

Sanders, E. & Stappers, P. (2008) Co-creation and the New Landscapes of Design. CoDesign: *International Journal of CoCreation and the Arts*, 4 (1): 5-18.

Schön, D. (1983) **The Reflective Practioner, How Professionals Think in Action**. New York: Basic Books.

Scrivener, S. & Chapman, P. (2004) The Practical Implications of Applying a Theory of Practice Based Research: A Case Study. *Working Papers in Art and Design*. [Internet] http://www.herts.ac.uk/__data/assets/pdf_file/0019/12367/WPIAAD_vol3_scrivener_chapman.pdf [Accessed 03/08/15].

Shumack, K. (2015) Creative designerly mapping: using scenario thinking and co-design to infom a hybrid approach to design research. In J. Simonsen and T. Robertson (2013) *Routledge International Handbook of Participatory Design*, 236-247. New York: Routledge.

Wagner, P. (2014) Foreword. In J. Lee, *Material Alchemy*, 7-9. Amsterdam: BIS Publishers.

FIGURE CAPTIONS

Figure 1: Pleated felt material coated with porcelain.

Figure 2 : Kevlar and silica material experiments with porcelain slip.

Figure 3: Textile fragments after the firing process.

Figure 4: Systematic combination of textile processes and materials.

Figure 5: Kynol and basalt samples coated in porcelain before the firing process.

Figure 6: Remains of Kynol and basalt samples after the firing process.

Figure 7: Screen printing porcelain onto fabrics.

Figure 8: Screen printing porcelain onto paper clay and silica fabrics.

Figure 9: Systematic reflection through photographic documentation.

Figure 10: Slipcasting combining textiles and once fired slip.

Figure 11: Selected techniques from participatory workshop to be developed in phase 6.

Figure 12: Handling of material during the participatory workshop.

Figure 13: Photographic documentation as a systematic reflection tool.

Figure 14 : Slipcasting during the participatory workshop.

Figure 15: Variety of hybrid material test samples developed in phase 2 and 4 of this project.