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Computer technologies and transdisciplinary discourse: critical drivers for hybrid design practice?

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We report on the findings of an ongoing, practice-based and critically grounded PhD research project. It has been recognised that an increasing number of practitioners are able and willing to negotiate working across the disciplinary domains of architecture, product design and sculpture. It is proposed that computer-aided design and manufacturing technologies can enable new models of practice. This paper positions the notion of transdisciplinarity as a critical driver for design vocabularies and methods towards an indicated new object grammar. Existing exemplary projects are reviewed to critically map how an increased level of sophistication in the implementation of these technologies contributes to design discourse in a cross-disciplinary manner. An existing technology adoption model is referenced to provide examples of integration which are understandable across discourse communities. It is indicated that there is a need for further research to identify and establish the benefits and limitations of this model of practice.

Keywords: Architecture; CAD/CAM; Objects; Product design; Sculpture

1. Introduction

The present study has emerged from the respective practices of the authors, which encompass: industrial design and manufacture; architectural collaborations; exhibition curation; and fine art practice. To this end, various computer technologies have been used as a vehicle by which to navigate the disciplinary boundaries encountered. These technologies include: computer-aided design (CAD), 3D object scanning, rapid prototyping (RP) and industrial rapid manufacturing (RM) technologies such as computer numerically controlled (CNC) cutting/milling technologies. The basis of the argument developed in this paper is the recognition that an increasing number of practitioners are able and willing to negotiate working across previously designated disciplinary

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domains in this way. This has led to the research proposition that these technologies have enabled a model of practice to emerge that both engages in recognisable cross-disciplinary discourse yet also yields greater integration and convergence between distinct axiomatic domains (in this case: architecture, product design and sculpture). The focus of the research is to investigate and assess the wider implications of this greater synthesis between these disciplines towards evolving vocabularies, methods, and intentions which speak of an emerging new object grammar. Therefore, the research is concerned with designed objects created from the application of industrial means, methods and processes (out with the strictly commercial environment) and cultural contexts which offer possibilities for new forms of convergent practice.

At the present time, the conjunction of technology and culture (within the domains outlined above) has shaped new creative opportunities which break with previous domain-specific models of practice. As these technologies become increasingly affordable and prevalent (Callicott 2001), and computing enters its pervasive, networked phase (McCullough 2004), the expectations we have of the objects we surround ourselves with might be transformed. Specifically, the outputs of the current dominant economic and corporate drivers might, to some extent, be replaced by artefacts and designed objects whose function is to provide alternate or parallel values to established design discourses. For example, these new objects may be designed to purposely subvert these established models, whereby the end-user is invited to reflect on their cultural role and/or the means of their creation. This has the result that new forms of consumption for audiences, users and/or co-creators of the objects produced might feasibly be developed (e.g. design for exhibition and/or publication in the manner of conventional fine art objects, design to order, mass-customisation, etc.).

2. Key terms of reference

Fundamental to the development of the critical stance outlined here, has been to position and accept the notion of cross-disciplinarity or transdisciplinarity as a critical driver for this research. The authors seek to more clearly establish and critically engage with this evolving discourse, which has led to the adoption of a number of key terms of reference and principles in order to make meaningful evaluations between such systems, projects and objects across domain-specific boundaries. Given that similar terminology is used with different intent and meaning from domain to domain, even among those sharing a common language, these terms of reference will be discussed as they arise within the text. The usage of the term 'transdisciplinary' as opposed to 'interdisciplinary' or even 'multidisciplinary' is an attempt to more clearly reflect the activities of practitioners that are dealing with the same issues and concerns across axiomatic disciplinary boundaries:

> Transdisciplinary. Further than inter-disciplinary work, in which different fields address separate problems inside a common framework, transdisciplinary research involves a stronger 'interpenetration of disciplinary epistemologies'. Effectively, this means new fused horizons become possible, beyond or transcending paradigms existing within single disciplines. Consciously pursued, transdisciplinarity is an approach to problem-solving suited to settings where disciplinary modes prove inadequate. (Century 1999.)

Furthermore, in order to understand if we are actually dealing with an emergent, transdisciplinary discourse, we have adopted Krippendorff's definition (Krippendorff

1995). This states that a discourse surfaces in a body of 'textual matter' which consists of artefacts, records, reviews and criticism which should remain meaningful or understandable by members of a discourse community but also to practitioners of other discourses. A discourse in this sense justifies its identity to outsiders in dialogue and in response to challenges or contestations by members of other discourse communities. Therefore, it is our goal to demonstrate that there is a significant body of 'textual matter'—existing exemplary projects—that can be recognised and understood across the disciplinary boundaries, where the computer technologies operate as a *Lingua Franca*—something resembling a common language—across the discourse communities through the synthesis of formal vocabulary, methods and intentions.

We consider the question of materiality especially important for practitioners from the architecture, art and design (making) disciplines working with digital technologies to produce 'designed objects' (a flattened-out conception which encapsulates the entire range of physical things that we use to facilitate and mediate our lives). The idea that one might include architecture in this study might seem problematic, given the disciplinary disputations as to whether the products of some of the more experimental architectural practitioners can be called 'Architecture' since there have been relatively few buildings produced by these means. However, this is changing and there are increasing examples of building-sized, designed objects for urban spaces being designed and built in this way (see examples below). The term 'designed objects' for the output of these practices has been adopted from the School of the Art Institute of Chicago's 'Designed Objects' course. This borrows critically from existing practices such as product and industrial design, furniture design, architecture, collaborative practices and entrepreneurship. In this paper this is extended into the cultural sphere by the addition of sculpture to the field.

The notion that new transdisciplinary models of practice are being enabled by 3D computer technologies is emerging. It is suggested that this position ignores the hierarchical distinctions of conventional architecture, art and design discourse and practice and might be more clearly seen or referenced within an expanded cultural field. Increasingly practitioners from across a broad range of disciplines are exploring approaches that develop the space or interstices between architecture, art and design, to bring about new types of critical, cultural, and/or technological objects which express a developing production grammar resulting from these technologies. This directly impacts on the scope and ambition of practitioners to develop new opportunities and new economic paradigms for cultural 'content providers'—such as the mass production of unique objects, the mass distribution of conceptual products and the creation of new orders of object that exist in the *terrain vague* between these domains. 'Terrain vague' is a term used to describe ambiguous, unresolved, and marginalised spaces in the urban landscape, such as industrial wastelands and monotonous suburban developments (Solà-Morales Rubió 1995). We are using this term here to refer to practices that fall between the mainstream discourses of architecture, art and design.

The community of interest which this research addresses are practitioners (a discourse community) made up of artists, architects and designers that apply industrial technologies to unconventional ends. Moreover, each of these distinct communities of practice has a certain amount of shared understanding, common points of reference and an ongoing domain-based discourse. However, in attempting to define this expanded community we are investigating notions of communities of practice around particular issues of common concern (those actively engaged in these technologies). The distinct communities of practice may attribute different meanings and importance to these 'boundary objects' but they collectively contribute to the body of knowledge and enable

processes which seem to bring the discourses together as a means of coordination and alignment (Hensel *et al*. 2004).

> Boundary objects are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use and become strongly structured in individual-site use ... Such objects have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities (Bowker and Star 1999).

3. A new object grammar

From this position of transdisciplinarity, the potential of boundary objects to speak of the same issues and concerns but from across axiomatic boundaries has enormous potential. This convergence has been enabled and accelerated by the development, proliferation and pervasive nature of computer visualisation and manufacturing processes—discoveries in one area are likely to 'feed' applications and implications within another. This 'flattened', transdisciplinary approach represents a material culture way of thinking about the disciplines. The common assumption underlying material culture research is that objects made or modified by humans, reflect the belief patterns of individuals who made, commissioned, purchased, or used them, and, by extension, the belief patterns of the larger society of which they are a part. Although each of the indicated disciplines of architecture, art and design takes as axiomatic the particular character of their domain, the research project takes the material culture point of view which treats them as subdisciplinary parts of a larger totality (Miller 1998). This technologically driven levelling-out of traditional, disciplinary hierarchies we suggest might be considered as having close affinity with Bauhaus and Soviet architects, artists and designers who saw industrial modes of production as vehicles for moving art into life, in which many artists championed the industrial artefact—generated mechanically and consumed collectively—over the singular work of aesthetic contemplation' (Lupton 1998).

While these historical movements do offer some interesting parallels (each movement appears to be precipitated by significant technological and cultural revolutions), the research is focused on what is unique with regard to the adoption of computer technologies. The late 20th century saw computing technologies become increasingly affordable and prevalent, resulting in a kind of democratisation of the 3D technologies and the production processes more commonly associated with industrial patronage (Von Hippel 2005). The direct result of this is practitioners have been provided with an increasing degree of liberation from *how* an object is produced (assuming that appropriate resources and access to technology are available) to more clearly focus on *what* those objects might be. The research, in this sense, seeks to track practitioners' engagement across the fields of art, design and architecture as they enter this phase and ask new questions about the cultural context of these new orders of objects.

The authors speculate that this may form a new object grammar—meaning systems, rules or underlying principles that contribute to our understanding of a visual language—in this case, comprised of both morphology (form) and syntax (function and context) in

the above-determined field of designed objects. A vocabulary for objects that eclipses conventional tropes and occupies the territory (terrain vague) between art, design and architecture poses fascinating questions about the cultural context of such objects which might engage with a reflexive discourse and second-order understanding (Krippendorff 1995) of the processes and products of design itself. This provocative and challenging position might question the very cultural and aesthetic limits of objects which are produced with intentions beyond conforming to cultural, social, technical and economic expectations (Dunne 1999), and/or fixed, means-end relationships (Rammert 1999).

4. The expanding field of design

So, why should engaging in transdisciplinary, design-based discourses from across conventional domains prove an attractive strategy to practitioners from current, clearly established, axiomatic domains? Of these domains 'design' is distinctive in that the term itself is used as both a noun and a verb, placing emphasis on what practitioners do, rather than what they produce (Flusser 1999; Fairs 2004). 'Art' and 'architecture' are products, whereas 'design' is a process. Rather than being a weakness, as has been discussed elsewhere (Krippendorff 1995), this condition can be viewed as an advantage. Indeed, the impetus behind the call to 'redesign design' is the defence of the discipline from colonisation from 'harder' disciplines such as engineering, marketing, and business. Arguably from this point of view, design is now also under threat from the 'softer' discipline of art. The position this research adopts proposes that this situation can be viewed as a strategic advantage, as it affords practitioners an expanded (transdisciplinary) discourse and an opportunity to engage with a range of new aesthetic, cultural, psychological, economic and social conditions.

The professional field of design appears to be caught in a perpetual cultural tug of war between Enlightenment rationalism and Romantic expressionism (Storkerson 1997). It is interesting to note that etymologically the root of the word 'design' is connected to 'art' and 'technology'. Historically, art and technology have moved into and out of positions of segregation and convergence with design forming a bridge between the two (Flusser 1999). Contemporary design in this sense has long since broken with narrow association with function (Fairs 2004). However, strongly contested oppositional arguments as to what constitutes design are still being articulated. This is most recently illustrated by the disagreement at London's Design Museum between ex-Chairman James Dyson and Director Alice Rawsthorn (Fairs 2004). This collision of ideologies appears to have emerged out of a tacit redefinition of what design can be; from an expanded perspective and in light of the impact of a transition to an information-based economy. Evidently the pervasive functionalist philosophy of design as espoused in the Bauhaus dictum 'form follows function' can still be tracked, but now might be seen to be subsumed by the desire to embody user expectations in terms of attractiveness, behaviour, and the emotional qualities of these commodities.

However, by viewing design in these terms as an integrative discipline and the generator of hybrid cultural forms it presents the profession with opportunities to rethink design as a cultural driver of enormous magnitude in the conjunction of these other domains. Indeed, this conception of design has been put forward as a role that is fundamental to the continual reinvigoration of the arts and culture (Coles 2005; Cox 2005). If it is accepted that the design of everyday objects is increasingly concerned with culture and the communication of the meaning of a product or its use (Norman 2004), then designers and architects will continue to explore approaches that develop the

potential of the space between fine art and design—to provoke and make manifest our relationships with the objects we imagine, design and produce.

5. Technology adoption and integration phases

This research seeks to critically map how these technologies impact on current defined disciplinary boundaries and areas of practice within this evolving hybrid, convergent field. This process is not mapped chronologically but rather defined in terms of increased levels of sophistication and implementation of technologies towards the development of a new object grammar beyond a rigorous consumer context. In the preliminary research undertaken we have characterised distinct levels of innovation in the application of these technologies. It is the authors' intention then to begin to define analytical terms in order to draw distinctions between projects across the disciplinary boundaries; and to outline and track trends in the convergence of disciplines brought about by the use of common technology and transdisciplinary practices.

In figure 1 we have tried to show that each of the distinct disciplinary axiomatic domains of architecture, product design and sculpture (within the broader field of designed objects) draws from the common, integrative technologies while being located within a continuum of transdisciplinary discourse. Speculative new hybrid domains—between the axioms—emerge from the use of these technologies but are also located within and contribute to the discourse. The proposed new object grammar develops out of the use of the technologies and engagement with the discourse as creative experiments;

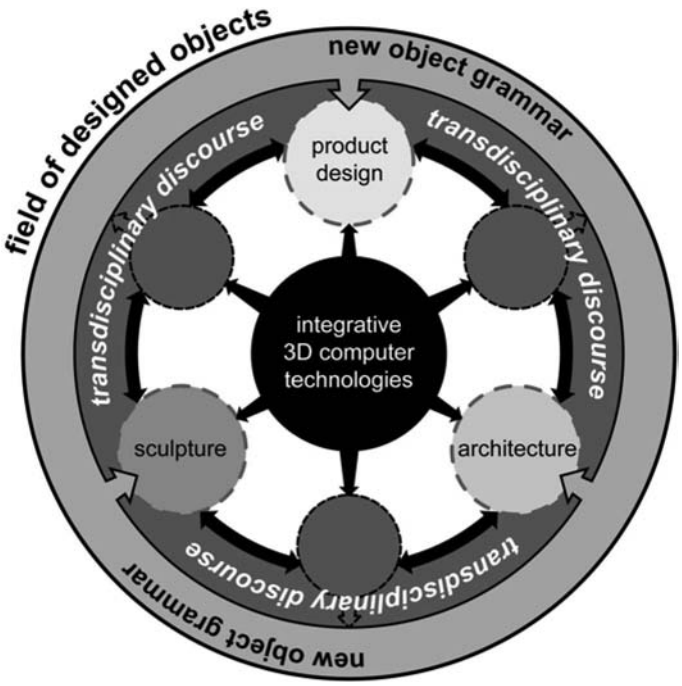

Figure 1. A proposed model of the relationship between integrative, 3D computer technologies and transdisciplinary discourse—critical drivers for hybrid design practice and a new object grammar in the expanding field of designed objects.

which are seeded back as innovations to be integrated into the axioms and the ongoing discourse.

Previously, the authors have applied other analytical ways of qualifying distinctions between these emergent practices (Marshall and Pengelly 2005a,b). In looking at projects across disciplines in terms of adoption and integration of computer technologies, the 'Apple classrooms of tomorrow' project (ACOT, which ran between 1985 and 1998 and documented how learning and teaching changed in technology-enhanced, elementary school education in the USA) provided a useful model of phasing to the levels of technological innovation and integration demonstrated in the projects reviewed. In order to more clearly develop a transdisciplinary, critical language for the purpose of evaluating work across these related but, until now, distinct domains of architecture, art and design practice we have borrowed the following phase definitions from the ACOT project to indicate the critical transitions between integration and innovation.

- **Entry Phase**—wherein practitioners are learning the basics of the new technologies. Methods of working and outputs remain largely derivative of the canon of conventional disciplinary practice, augmented by superficial experimentation with the new tool set.
- **Adoption Phase**—the computer technologies are beginning to become integrated with traditional disciplinary practices. Although the methods of working have changed, the outputs remain as an extension of the practitioner's discourse.
- **Adaptation Phase**—use of computer technologies has become consistent; with productivity and efficiency as the primary contributions made by the use of the technologies. This phase is analogous to the conventional use of the technologies within an industrial context.
- **Appropriation Phase**—is an extension of the previous three phases wherein the practitioner displays a developing command and understanding of the technologies to the point where innovative applications and discontinuities with previous models of practice emerge. At this phase, projects are more likely to engage in a recognisable cross-disciplinary discourse as new situations beyond single disciplinary paradigms are explored.
- **Invention Phase**—is deemed less an actual phase than a mindset, implying willingness to experiment and change. As such this correlates to our proposition that a new object grammar and a new hybrid domain has been achieved which remains meaningful and understandable to members of the practitioner's discourse community but also to practitioners of other discourses. As such, the resulting artefacts offer counter-propositions and critical technical practice to the main disciplinary discourse through radical innovation of a wholly different order from the Entry Phase.

Of the artefacts surveyed, those that were produced by practitioners trained within the discourse communities of architecture and design were more likely to feature in a more advanced phase than those produced by practitioners trained in the discourse community of sculpture. We speculate that this is because formal training and access to computer technologies is not yet deeply embedded in the pedagogy of this community. Further work is proposed to determine whether this is actually the case. However, in the current study we have chosen to focus on an investigation of examples where clearly potential transdisciplinary blurring is already occurring. This disciplinary blurring is not without historical precedent as pointed out by Barbara J. Bloemink in the recent exhibition

'Design ≠ Art' at the Cooper-Hewitt, National Design Museum in New York (Bloemink 2004).

6. Examples of entry and adoption phases

Today we have come to expect to freely customise music, photographic and moving images, all from the comfort of a personal portable computer. This ability and expectation to customise and re-mediate our visual surroundings and experiences now also includes the ability to virtually and physically manipulate and reproduce the objects and artefacts we choose to surround ourselves with. Using 3D imaging hardware and optical geometry processing software; the spatial, colour and textural information of objects can be scanned, digitised, sampled, altered and archived. However, many artists engaged with computer technologies have produced software-derived, sculptural objects that are still grounded in the formal qualities associated with the plastic sculptural arts in the tradition of the work produced in the 1930s by canonical artists such as H. Moore and N. Gabo using the technologies to surpass them only in terms of more convoluted geometric complexity. For example, compare the formal similarities between two polished bronze sculptures created 65 years apart—Jean Arp's manually generated 'Shell and Head', 1933, which is composed of two intertwined, organic forms, and Keith Brown's first RP sculpture, the digitally generated 'Continuity of Form' from the CALM (Creating Art with Layer Manufacture) project, 1998. Brown's sculpture was generated in the 3D modelling application 3ds Max® from a Torus Knot primitive which has been extensively 'massaged' by adjusting its parameterisation incrementally via the software interface (numerical spinners). Brown used his extensive experience as a traditional sculptor to make visual-based, qualitative decisions on the development of the form in much the same way that Arp would have via manipulation of physical matter. Brown's resulting mesh was then output to a Selective Laser Sintering machine and built up layer by layer from Nylon powder with a CO_2 laser. Once built, the form was cast in bronze using the same traditional, lost wax casting processes that Arp would have used from his original plaster forms in 1933. The innovation here is that Brown's form (at least while digital) effectively passes through itself—a condition rendered superficial (literally, on the surface) once the object is cast as a solid lump of bronze. Also, finer edges and incidental Moiré patterns (stairstepping) across the surface have been achieved as artifacts of the digital 'printing' process that could not be created with manual modelling processes. However, these have been lost or undermined to a great degree through the process of cleaning and polishing the cast bronze. Arp's form attains visual complexity through the conjunction of two separate forms; Brown achieves greater visual complexity through the manipulation of a single digital entity. (Arp image available online at: http://www.guggenheimcollection.org/site/artist_work_md_8_6.html; Brown image available online at: http://www.uclan.ac.uk/clt/calm/brown.htm).

The objects produced by practitioners exposed to these technologies primarily from fine art backgrounds have on the whole sought creative results which explore the suite of new 3D modelling software tools available rather than the development of a new visual/object grammar. As such they tend to fall into the Entry Phase or the Adoption Phase as discussed above. In many of the cases examined, the maker's concerns with *what* the object is are largely subsumed into the *wow* factor of *how* it came into being. These works tend to be the results of a dialectical engagement between the artist and the tools used which seldom engage with a context or discourse beyond that of formal art historical studies. This work can also be characterised by the lack of an attempt to participate with

an audience beyond the level of providing visual phenomena for aesthetic contemplation. Further examples of this are available at: http://www.uclan.ac.uk/clt/calm/overview.htm; http://www.bostoncyberarts.org/mindmatter/mimtitle.html; http://telesculpture.prism.asu.edu.

Innovation here is largely the augmentation of existing visual practices by means of the application of computer technologies. Examples of these 'wow of the how' works frequently make use of the most basic of 3D manipulations such as modifiers that allow the user to perform operations on the geometric structure of a digital object. For example, when you apply a twist modifier to a mesh, the position of each vertex of the object is changed to produce the twisting effect. These might be considered the 'Photoshop Filters' of 3D—processes programmed into the software applications allowing any user to achieve complex, recognisable and reproducible results with a minimum of purpose or intent. Other examples include the use of parametric, 3D human figure generation software and the use of freely available pre-modelled assets from online sources—3D clip art sculpture. Although the development of these works is noteworthy within the domain of sculpture, in the current study we will set these aside to concentrate on the transdisciplinary nature of other examples using these technologies.

6.1 *Examples of Appropriation Phase*

This Appropriation Phase represents a shift in order of magnitude in the level of engagement and sophistication of the artefacts towards an application of the technologies beyond their conventional industrial usage which occurs at the Adaptation Phase. The artefacts produced at this phase might be considered experimental in nature, with the objects having been made purposefully to exploit the technologies used—presenting an opportunity to reframe the activities, methods and knowledge of those engaged.

Janne Kyttanen and Jiri Evenhuis' Amsterdam-based design research company, Freedom of Creation, produces Rapid Manufactured commercial products and also develops new Rapid Manufactured textiles. They work on self-initiated as well as sponsored projects with industrial partners and universities (http://www.freedomofcreation.com/).

The Camera Obscura for Greenport, Long Island, New York is by architecture firm Sharples Holden Pasquarelli's (SHoP). It claims to be the first building to be entirely computer-designed and CNC fabricated. The structure consists of a kit of 750 digitally designed, custom-made parts in a manner more usually associated with producing a consumer product (http://www.shoparc.com/).

These practitioners are actively investigating and exploiting computer technologies to achieve innovation in terms of both the conceptual design process and also the designed objects produced. By engaging with new sets of technologically driven, creative, cultural and economic conditions they are stimulating intriguing alternative forms of inquiry. While much of the work in this area exists as research; its impact is potentially significant for current professional and academic models.

7. Examples of invention phase

There now follow examples of the Invention Phase projects that evidence a transdisciplinary digital praxis which exploits CAD and manufacturing processes which might challenge cultural, creative and economic conditional norms. The authors propose that these projects offer tangible opportunities for disciplines to engage in higher-level transdisciplinary discourse around linking practices towards the development of new

skills sets and design methodologies. It is expected that these new models of disciplinary practice will continue to exist alongside the traditional models and act as a means of exploring innovative design processes. This signifies a multidirectional morphing of disciplines and the opportunity to create fundamentally new types of designed objects and practices that eclipse conventional tropes. There are increasing examples of work which explore the technological potential of this area. These practitioners are investigating the application of technologies and have posited new questions about the cultural context of objects. Within the speculative transdisciplinary, technological, integration of the Invention Phase we offer the following (far from exhaustive) four categories of innovation: Materiality, Heterarchical Implementation and Algorithmic Design as examples of applications of the common computer technologies that have resulted in increased synthesis between these disciplines through evolving vocabularies and methods; and Fictional/Conceptual Product Design as an example of engagement with a transdisciplinary discourse which uses knowledge of technological design processes towards the development of 'object variants' (i.e. modifications; creative departures, options, substitutes, mutations or evolutionary trajectories), arrived at through an engagement with specific technologies and production methods.

7.1 *Materiality*

'Materiality' connotes the generative use of new production processes and the exploitation of unique features of these technologies, both software- and hardware-driven. As production methods become more sophisticated and accessible, new creative possibilities arise that would not have been possible previously. Non-standard means of manufacturing and new material processes co-evolve to allow the implementation of organic forms regardless of scale or function.

Thomas Heatherwick Studio: this London-based design studio's projects range from products and urban design to civil engineering and public art. Heatherwick applies his skills as a 3D designer to create urban sculptural objects and iconic and functional spaces. For example, the Buddhist temple proposed for Kagoshima, Japan (currently in fundraising), created from a 3D scan of a piece of folded cloth and is to be built up out of 450 layers of plywood and glass arranged in steps, in a somewhat contrary, 'making-analogue' (on an architectural scale) of digital, layer-manufacturing processes. Similarly, Heatherwick's 'Bleigiessen' is made from the 'point cloud' (the collection of points in 3D space resulting from the digital scanning of an object—in this instance, a blob of molten lead cooled in water). The 30-m tall sculpture which consists of 150,000 glass spheres, suspended on a million metres of stainless steel wire, is in the atrium of the Wellcome Trust headquarters in London. (http://www.icon-magazine.co.uk/issues/january/heatherwick.htm).

NIO Architecten's 'Amazing Whale Jaw', at the bus station at Spaarne Hospital in Hoofddorp, The Netherlands was CNC machined from polystyrene and coated with polyester resin. The various parts were transported to the site and glued together, before receiving a final coat of polyester. It is the world's largest structure made of synthetic materials. (http://www.nio.nl/).

7.2 *Heterarchical Implementation*

'Heterarchical Implementation' is the adaptation, customisation and personalisation of objects involving the end-user or audience as a co-designer—resulting in 'tailored'

objects. Sophisticated, non-standard production processes circumvent the serial mass production model (Von Hippel 2005), empowering the 'third party' user of the designed object through the application of user input and computer-controlled machinery.

Karin Sander's '1:10' consists of 40 figures produced by 3D scanning actual people. The data from the scans are used to make the figures at 10% of life size by the process of fused deposition modelling in ABS plastic. The figure is then painted from photographs by a technician. The result is an exhibition of figurative sculpture made through a highly conceptual program of activity that is executed by various technologies and leaves the objects untouched by Sander herself. (http://www.karinsander.de/).

Oliver Vogt and Hermann Weizenegger's 'Sinterchair®' is made by the Selective Laser Sintering process (in which Nylon powder is applied in fine layers and sintered in a series of 2D sections by a CO_2 laser to form a 3D object). The product is computer-generated from input from the customer. Vogt + Weizenegger use questionnaires to find out about the customer's preferences and therefore Sinterchair® is a mass-customised object. (http://www.vogtweizenegger.de/).

7.3 *Algorithmic Design*

'Algorithmic Design' indicates the use of software as an autonomous, generative tool increasing the opportunity for serendipitous design. As computer/practitioner interactions become more sophisticated, possibilities have shifted away from productivity tools and moved towards opportunities for design experimentation. One of these is generative design. This can be defined as the approach of developing software processes and applications which can evolve structures and objects at various levels of autonomy, based on predetermined rules, conditions and variables.

Michael Rees and Chris Burnett's Sculptural User Interface® is a software tool which, through the use of procedures and algorithms working in series, creates cybernetic assemblage from text. The reference system explicitly involves language either generated within the program or introduced by the user via the keyboard. (http://www.michaelrees.com/).

Lionel T. Dean's 'Future Factories' concept creates designed objects by setting ranges within which random values (assigned by a computer) determine certain defining parameters of the objects. This allows aspects of the form of the objects to 'mutate' sequentially within certain interrelated parametric ranges. (http://www.futurefactories.com/).

7.4 *Fictional/conceptual product design*

Artists and designers not limited by being defined as one or the other are developing innovative products and artefacts which challenge cultural, creative and economic conditional norms. These artefacts tread the line between artist multiples and critical designed objects. They often subvert the traditional product development cycle. This is such a current trend that it forms a constituent thread of the ISEA 2006 Symposium with the 'Edgy Products' call for work by 'artists and designers who are manipulating, hacking, subverting, queering, hijacking, recombining, or reformulating the notion of product'. (http://isea2006.sjsu.edu/edgyproducts/). One of the eminent members of the selection committee for this exhibition is Anthony Dunne, who together with partner Fiona Raby (http://www.dunneandraby.co.uk/) has been instrumental in examining the designed object agenda in which physical design models or prototypes are 'to be considered as a model in the same sense as a mathematical or cognitive model.

This enlarged view of the model is already accepted in architecture and fine art' (Dunne 1999).

Much of Tobi Wong's work treats design as medium rather than a discipline. He has coined the terms 'paraconceptual' (of, relating to, or being conceptual) for his original productions and 'readydesigned' to describe the products he creatively reworks (after artist M. Duchamp's term 'readymade', meaning art created from common objects that are not normally considered art). The objects explore the visual language of consumerism and they are often very amusing—such as in the case of the Bubble Club Armchair by Philippe Starck turned into a lamp, titled 'This is a lamp' (obliquely referencing the Surrealist painting 'The Treason of Images' which shows a pipe with the text (in French) 'this is not a pipe' by René Magritte, 1928), and exploits the translucent qualities of this polyethylene design icon (http://www.brokenoff.com/).

After Ito Morabito was kicked out of design school after only a year, he decided to use renderings of 'un-released products' as cultural interventions. His then fictional company, Ora Ito, designed fake products for well known companies and he published them on his website. The hijacked brands became aware of this when they were inundated with orders for these virtual products. Fiction became reality when Ora Ito was subsequently hired for genuine, high-profile design jobs (http://www.ora-ito.com/).

In these examples, the synthesis of vocabularies, methods, and intentions is indicative of an emerging and evolving transdisciplinary discourse and can be viewed in terms of experiments in the field of enquiry alluded to in this paper.

8. Contribution of research

This research is important at this time because the design disciplines and creative industries are experiencing discontinuities with previous models of academic and professional practice arising out of globalisation and new information-based economic paradigms. New technologies are implicated as both cause and potential solution of this issue. The Cox review of creativity in business (Cox 2005) recommends multidisciplinary design education. Can a transdisciplinary model built on adaptation, appropriation and synthesis offer a better way to enable individual practitioners to determine their own future? Further research is needed to explore the elements of design thinking, approaches, processes and methods that might be applied more broadly to understand and exploit these new technologies. There are dramatic implications for the education and training of the next generation of students. One possible strategy that practitioners have at their disposal is to work with others in partnerships and teams. Collective practice necessitates developing particular sets of skills in which negotiation, compromise and the ability to develop shared language is a priority. The authors propose that a transdisciplinary discourse is a means by which to begin to investigate and assess this expanded field and the cultural context of these new forms of convergent practice.

The practice-based and critically grounded PhD research project this paper draws on ('An exploration of transdisciplinary discourse through the application of 3D computer technologies in hybrid art and design practice') being undertaken by the primary author has emerged from the data generated through ongoing professional practice and engagement with this transdisciplinary domain. The researcher has exploited the opportunities presented by the conjunction of his experience from industry and coordinating artist-led organisations and the curation of projects facilitating artists' use of rapid-prototyping technologies. The research project provides an opportunity to build on and examine critically this significant engagement from an informed position towards

greater critical understanding of the current usage of 3D computer technologies in architecture, art and design.

9. Conclusion

The argument developed in this paper is that an increasing number of practitioners are engaging in a recognisable cross-disciplinary discourse that yields greater integration and convergence between the distinct axiomatic domains of architecture, product design and sculpture. The application of common computer technologies has resulted in increased synthesis between these disciplines through evolving vocabularies, methods, and intentions that can be viewed as an emerging new object grammar. This development is significant as it indicates expanded opportunities for practitioners and the possibility of developing new hybrid forms of practice and discourse. Subsequently, this suggests new forms of consumption for audiences, users and/or co-creators of the objects produced.

Most of the designed objects that we live among have a basic functional purpose—designed objects are not necessarily Art or Architecture, although most works of Art or Architecture have been designed. Particularly in the practice of public art we have seen the convergence of these disciplines. With the advent of computer technologies this overlapping area is expanding and entering into new possibilities. Public art is art plus a function, whether the function is to provide a place to sit, to mark a significant event, or to focus the public's perceptions of a site. Design is the integrative process by which aesthetic, cultural, social, technical and economic potential is imagined and then translated to give order to objects, environments and activities. Through the alternative design strategies discussed above, and others like them, practitioners from across domains are exploring the aesthetic and provocative possibilities of objects that engage audiences and users with a range of aesthetic, cultural, psychological and social issues.

Objects created either by active pursuit of this transdisciplinary discourse or through integration via exploration of the indicated computer technologies remain meaningful, understandable and significant not only to members of a specific discourse community but also to practitioners from other discourses. This transdisciplinary discourse is identifiable to outsiders as the computer technologies operate as a common language maintaining coherence across the intersecting communities. This speculative new object grammar comprised of form, function and context represents a vocabulary for an expanded field of designed objects that spans the practices of art, design and architecture. This research seeks to critically map how increased levels of sophistication and implementation of these technologies contribute to design discourse within this evolving hybrid, convergent field. There is a great need for further research to identify how the adoption of technologies enables these transitions.

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