Material Matters: Lowering barriers to uptake, Diversifying range of application, Carrying forward legacy processes.

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Abstract:

New production technologies and modes of enterprise based on proprietary and cost-effective, open-source production platforms are changing the nature of making. An exemplar of this change, 3D Printing has created a rapidly developing presence as an emergent production technology across many sectors. As this technology's development continues, artists and designers are no longer constrained by traditional models of form development and production: accessible 3D technology stands to markedly revise a broad range of legacy production practices.

Material Matters - a research cluster within the Intersections Digital Studios of the Emily Carr University of Art and Design - is exploring these new digital technologies as a viable analogue to traditional methods and materials. As 3D printing becomes less expensive, more powerful and more pervasive it diffuses into a wider range of opportunities. As these new means of creative production emerge they intersect with established practice, Material Matters examines these points of contact with an emphasis on four interrelated components: material development and lateral application; and commercial application and partnership. This paper will highlight elements of these four streams.

Introduction:

3D printing is an emergent digital technology experiencing explosive growth; a proliferation of applications and technologies is multiplying across a very broad spectrum of activity. Within Canada and elsewhere in North America, Europe and Asia 3D printing is evolving rapidly as a material production platform with a very broad rage of application.

Recent years have born witness to a strong consolidation of technology and service with wide commercial market speculation on this potentially revolutionary wave of personal manufacturing or DDM Direct Digital Manufacturing (Singer P. etal. 2011). Consolidation of the commercial market is made doubly evident by the recent mergers of the major North American commercial 3D print technology manufacturers and suppliers; 3DSystems and Z-Corp, and most recently; Stratasys and Objet (Hurst, N. 2013). These companies have previously defined the four corners of the North American Commercial market's share for 3D print service, technology and material systems. Governments are responding in kind with sizable new investment of their own. The US government is establishing a national center for additive manufacturing in the Midwest. (70 million dollars US) (whitehouse.gov, 2012) with similar investments in the UK, Singapore, Japan and China. This backing is strong material proof of the credence placed on the staying power of the technology. As with traditional manufacturing processes, 3D printing - which is often connected to notions of Appropriate Technologies (AT), (Pearce, JM. 2010) - invites institutional investment on a grand scale. The fundamental principles of investment, research and development drive commercial expansion in this sector and yet the methods of making integral to 3D printing are in flux and on the precipice of significant change.

Additive manufacturing technologies are built upon an extremely fluid digital infrastructure that allows for a level of public participation and interaction that is unprecedented. Powerful computer systems, affordable, full-featured 3D modeling programs, and high-speed communications networks allow for the design, production, sharing and refinement of any aspect of 3D printing architecture. As a result, an open-source community is driving the demand, development and distribution of cheap high-resolution 3D material technology. Easily slotting into a home workshop, a studio, an office or emergent make-space, open-source 3D printers have equipped the eager, engaged consumer with an affordable means of 3D form production. Further, Open-Source Appropriate Technology (OSAT) (Pearce, JM. 2012) and the widespread search for increasing economy in material cost, selection, and ecological impact are rapidly re-defining what it means to have a sustainable small-scale personal production platform.

Material Matters is examining a diversity of conceptually interlinked inquiries framed by the multiple developments within this new production platform. We are developing alternate pathways to object making that conflates these new digital opportunities with the inherent strength of legacy process. Conceived as symbiotic methods - rather than discreet, self-contained systems - we are examining new appropriate pathways to production. Our work explores how new technological means of production can: interconnect with and carry forward legacy process (rather than simply supplanting them); create scalable fabrication methods that capitalize on 3D printing's innate link to customization; engage a broad spectrum of practitioners on both an industrial and individual level.

Example 1: reformulate commercial consumables to drastically reduce cost.

3D printing is a technology with the capability to produce virtually any type of form regardless of its complexity, in a broad range of materials. Despite this asset there are distinct barriers to uptake. Commercial 3D printers produce objects of high resolution with high reliability, but at a relatively high cost. Most commercial systems operate within a closed loop - output equipment is tied to proprietary consumables – this arrangement produces an ongoing, reliable revenue stream to manufacturers but acts as a considerable disincentive to participation and exploration. Many printed objects tend to be limited by budgetary considerations rather than design intent or technological capacity.

The research out of Emily Carr University's Material Matters research stream is an outgrowth of the work lead by professor Mark Ganter at the University of Washington's Solheim Additive Manufacturing Laboratory. It seeks to replicate and replace industry based 3D printing consumables, adding leverage to the technology by making it more accessible. The physical constituents of commercial powder-based consumables (gypsum based, hygroscopic [moisture attracting], easily screed-able, strong green strength, high resolution output) were applied to a test regime designed to facilitate the replication of the required print medium characteristics. A series of seventy-five systematic iterative tests have enabled a powder formulation to be inferred through the application of readily available "off the shelf" constituents. This new formulation closely replicates commercial powder characteristics but at a 20X reduction in cost ($50Lb to ¢50Lb).

Figure 1: *a) Initial comparative tests (L) basic powder formulation (R) commercial powder, b) first "proof of concept" print with new powder formulation, c) selection of iterative tests – closest objects, commercial material, next closest, best formulation of "off the shelf" powder, d) processing powder for uniform consistency.*

Example 2: Integration with legacy process

The second trajectory of this research examines how the disruptive capacity of inexpensive object printing can be harnessed as a way to interconnect new digital methods with legacy processes (ceramic slip casting, non-ferrous metal casting).

Having devised a high performance, extremely low cost, printable powder has directly enabled the production of 3D printed objects at a much lower cost, reducing a significant barrier to both participation and exploration and in turn facilitated the production of an entirely different class of object moulds.

Figure 2 ceramic slip casting: *a) digital mould design, b) printed mould being removed from printer, c) ceramic objects slip cast from digital moulds, d) mould components prepped for slip casting.*

Figure 3 non-ferrous metal casting: *a) bronze ingot being melted in induction furnace, b) mould components printed and ready for casting, c) mould soon after being filled with molten bronze, d) removal of mould to reveal cast metal object.*

***Figure 4** a) detail of slip cast mould's complexity [mechanical fit], b) miniaturized and multiplied objects from original full size file c) detail of metal casting mould interior highlighting heat resistance, d) complexity of mould geometry e) finished aluminum cast from printed mould f) detail of cast skateboard truck immediately after casting [note fin flashing] g) multiple copies of skateboard truck mould prior to casting h) detail of ceramic slip cast on initial mould opening.*

Mould ready for casting can now be printed affordably, creating a digital workflow that jumps directly from the virtual (the digital model) to the actual (the cast-able mould) with no intervening steps. The moulds printed with this new powder formulation display two distinct and important characteristics 1) - they are hygroscopic (they want to absorb moisture) and 2) - they are refractory (they can withstand high heat). These characteristics have allowed two streams of inquiry to emerge based on: 1) – ceramic slip casting, and 2) – non-ferrous metal casting.

These digital moulds display multiple unique characteristics: they can have complex geometries difficult or impossible to create manually; they can be scaled, distorted, multiplied and edited at will; they can be used for extremely different types of cast-able materials; they can be easily recreated on demand, and "moulds" can easily be distributed and archived via digital media. Importantly, through this integration of traditional materials and methods, 3D printing is transitioned from outputting expensive facsimiles - plastic or plasters prototypes - to producing cost effective "end of line" objects in "true life" materials. Through reciprocal development, traditional means are enabling new digital methods and digital means are enabling new traditional methods.

Conclusion:

Technical developments and nascent material application act as points of leverage and convergence for innovation. Material Matters has explored an amalgam of discipline, methodology and pragmatics in a variety of ways. We have developed high resolution, printable powders that are orders of magnitude less expensive than their commercial equivalents; devised methods of cost effectively slip casting ceramic objects from 3D printed moulds with unique characteristics; and created new, inexpensive digital means of casting metal, reducing the number of production steps from 7 to 2. These ongoing developments are based on an examination of the multiple interconnections between the capacities of pure and applied research, the permeable membrane between convergent, practical investigation and divergent, creative application and the latent interdependence between new technological innovation and historic practice.

References:

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Philip Robbins holds an M.A. from the Royal College of Art in London, a B.A. from The Emily Carr University of Art and Design and a B.ed from the University of British Columbia. Philip's practice explores a *wide spectrum of materials, media and technology in a career that spans props production for film and television, public artwork and education. Since 2000 Philip has taught across a wide range of disciplines with an emphasis on material practice, 3D software and digital output technologies.*

Keith Doyle is an Adjunct Research Associate in Applied Arts at Emily Carr University of Art + Design. He is a Lead/co-lead Investigator on a few Emily Carr research initiatives including, the DnA project, cloTHING(s) as conversation, and a founding faculty member of Material Matters, a pragmatic material research cluster within the Intersections Digital Studios at Emily Carr University of Art + Design. Keith holds both a BFA and an MFA in Sculpture. He maintains an active material practice and is a recent Resident Artist at the ACME Studios International Artists Residency Programme situated in London, UK, a Banff New Media Institute alum, 2006-2007 as well as, a NYC Dance Theater Workshop Artist's Research Medialab fellow.

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