Digital Craft and Upcycling: Tools, Technique and Material

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***Abstract*—Materials produced from precious resources are often rejected prematurely, before their lifecycles are complete, due to changed circumstances, for being out of fashion, damaged or inappropriate. Some designers consider such discarded materials a valuable resource. In this design approach, they first recognise available material as a starting point for design and then establish a process for detailing. Digital tools can improve design in a broad range of possibilities, increasing the range and quality of solutions physically considered, but they can also create limitations for the process. This study reflects on the factors of influence of emerging digital methods for visualisation, design and fabrication towards upcycling and creativity industries focused on customised production methods. It aims to contribute to future technological development for digital upcycling and making.**

***Index Terms*—digital craft, design upcycling, design materiality**

I. Introduction

Recent developments in technology have heightened the need to renew design and production process. Digital tools have impacted all phases of designing from the first sketch to the manufacture of building components, products, pieces and assembly. They offer possibilities inconceivable a few years ago, but they also raise numerous questions regarding the challenges of integrating customised design with digital technologies and its ability to maintain reliable quality, with results similar to those shown during modelling.

Upcycling is an activity of experimentation. It requires 'substantive knowledge' such as creativity, repertory and spatial visualisation capability. Thus, computing allows all these activities virtually and improves value while minimises errors and failures during the process. It can also facilitate the basic structure of 'seeing-moving-seeing' [1] in design. To these advantages, Chakrabarti, Shea [2] add that digital tools can help designers explore new directions through a wider variety of possibilities, expanding the range of solutions manually considered. They can also decrease tedium in some tasks of design routine by automating them, leaving more time for creative activities. Technology, thus, can become the catalyst for humanising opportunities to occur, rather than an end to the means [3].

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'Digital making' or digital tools for supporting material production or transformation are becoming part of the essential tooling of contemporary design. However, as the craft activity, digital craft outcomes are closely interconnected to material, tools and technique. For upcycling, the material is readily available. This study presents arguments about potentialities and limitations on the digital craft, the challenges of design towards the extension of the lifecycle of materials.

II. Digital Tools and Craft

Traditionally, 'digital' design practice is attributed to the efficiency of a numerically precise way of operation. On the other hand, 'craft' is often related to the "realm of amateurish making, complete with mistakes, dropped stitches, fingerprints or other traces of human fault that are understood as being charming in the context of handmade human endeavor yet fall short when measured against 'serious' artistic categories that include architecture, design and fine art." [4] For many thinkers, however, digital manipulation is an advanced craft where mixed tools need to be applied to reach the final goal or meaning. Both Roke [4] and McCullough [5], for example, propose that craft need not be limited to the physical world - electronic form giving can also be a rewarding hands-on experience.

When analysing concerns about design process becoming "less a matter of putting oneself in the job and more about getting the most out of the machines" [5], Boza [3] observes that one should focus on innovation and efficiency, as well as intuition and creativity. For him, coupling a systematically defined process of design/fabrication with intuitively responsive process through the hand's physical contact with the material, the designer or craftsperson gains experience and develop more refined knowledge about material manipulation and tool usage.

Over this issue, Poole [6] questions how advanced digital technologies and computational velocity has changed the way to give shape to our imagination. According to him, the speed to conceive and produce drawings and images has increased and so the rate of exchangeable data. However, his study states that although rapid prototyping methods allow designers to fabricate and arrange three dimension objects quickly, it barely gives the designer any insight into how the object could be mass-produced. Furthermore, it concludes that

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the speed of these digital processes gives little or no time for analysing the creation, and they cover unreal conditions, assuming that is no limit to formal conception. Thomas (2007) adds that digital-based mechanistic processes such as Computer Numerically Controlled (CNC) milling operations and rapid prototyping enable a direct link between conceptualization and production.

Dunn [7] is probably one of the best-known practitioners of digital possibilities, and while Poole assures that the synthetic smoothness of computer-generated images produces a false sense of technical resolution, he claims that visualisation techniques bring life to the imagination, generating extreme accurate scenes. He adds that "architecture is fundamentally concerned with two core activities: designing and making", and using digital tools since designing to materialisation embraces both [7p. 06]. According to Bechthold [8], design thinking was affected deeply by the emergence of powerful surface and solid modelling tools suggest that complex three-dimensional shapes can now be produced with a digital process. Even though it is partially true, there is an inconsistency with this statement as to carry out the complete process; there must be previously detailed considerations on structural limits and material features as well as technical expertise and skilled labour. Whatever their opinion on the limitation of methods, a significant and growing body of literature equally agree that digital tools offer a powerful, speedy, productive, scalable and precise data construction and manufacturing platform for architectural design and production.

However, researchers should be aware that the development of design methodologies proceeds more slowly than the development of computer-supported tools. The precise and sometimes customised interaction between methods and tools will provide better support in making decisions. There is, thus, need to adapt design methods to be used in combination with various tools, according to the design problem [9].

III. Design Resource

The lifecycle of materials is one of the most significant current discussions in the field. Chapman [10] explains one third of all planet's resources have been already consumed within the past four decades. Chapman adds that most products are incapable of sustaining a durable relationship with users as, in recent years, 25 percent of vacuum cleaners, 60 percent of stereos and even 90 percent of computers still function when people get rid of them.

The linear lifecycle of material flows tends to encourage people to throw things away before they are physically worn out or technically damaged only because they are out of fashion or, in their opinion, outdated. This fact is alarming when design seems to promote wastage instead of fostering sustainability.

A report on this topic shows that in the financial year of 2006-2007, 43.777.000 tonnes of waste were generated in Australia, which 52% was recycled and 48% sent to landfill [11]. This frame represents an important loss to the economy of material flows, as the very idea of waste belongs to the old way of thinking whereby waste is seen as a problem. Thinking ahead, Addis [12] suggests that, rather than seeing materials at the end of their 'first life' as trouble, they should be looked at as a great opportunity to extend the lifecycle of materials. Another view exemplifies nature and its system of nutrients and metabolisms in which there is no waste; one system's waste is another systems food. Therefore, waste equals food [13].

Australian Packing Covenant [14] registers that, although the recycling rate for packaging has increased from 39.2% in 2003 to 63.1% in 2011, almost 22 million tonnes of waste – most recyclable – are still sent to landfill each year. Of the total Australia's generated waste, 29% is composed of municipal solid waste; 33% is produced by commercial office buildings and industries; and 38% are originated during building, renovation and demolition of buildings, houses, roads and other elements of the built environment [11]. Though the more significant stream of waste generation is from construction chain, it has the highest recycling rate of 58%, while the municipal solid waste recycled index has reached only third part of its entire generation.

The intelligent handling of repurposing has become a pressing issue today but, in other ages, it was a total part of the society [15]. Designers are largely responsible for the creation of the built environment and vast contributions to the waste stream. It, therefore, stands the reason that they should be at the forefront of initiatives relating to reducing consumption and take maximum advantage of every production. Samsonow [16] notices this role clearly and adds that the solution is, instead of reversing technological advances, evaluating how people disregard so easily everything that has been created in light of new technologies and products. For some designers, this stream comprises a valuable source of the risk and creativeness of upcycling design.

IV. Design for Upcycling

Upcycling will not be a common practice adopted in the architectural field for next decades, while resources are still accessible for the production of new goods. It embraces design approaches focused on materiality since the discovering to the (re)application of available resources and, although the literature on processes and definitions is yet raw and contradictory, the attitude has been encouraged to prolong the life of the existing material.

However, this activity demands additional time, effort, inventiveness and spatial visualization capabilities. Trying to extend the life-cycle of materials involves risk, multiple attempts and often results in failure or abandonment and this can be attributed to the lack of an established methods for design for material re-contextualization. In light of the above, the main objective of this study is to investigate how to extend the lifecycle of materials through a new means-oriented methodology for architectural design and material practice.

When designing for upcycling, information regarding the material consists of the constants of the process and all the information need to be embedded in the process. Tools and techniques englobe the variables. The interaction concerning constants and variables influences the design decisions and the final product. The main difference between the design approach for upcycling and the traditional design it that, unconventionally, material information requires to be learned before the process start. Thus, while digital crafting, a proper input of information is crucial.

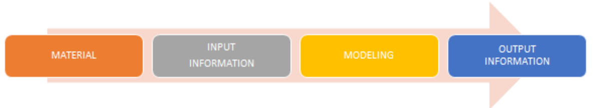

Figure 1. Process for material learning in design upcycling

V. Methodology

To illustrate this relevancy and interdependency, 31 second year students were challenged to design and build self-supporting panels measuring 1,2m X 1,2m from uneven reclaimed material during a 9 weeks' studio unit at Curtin University, Department of Interior Architecture. The students used the infrastructure from workshops where they were supervised and offered introductory manufacturing training.

The initial three weeks was focused on the design development, documentation and individual proposals to be prototyped in cardboard. The assessment of the cardboard models followed criteria based specially on stability. From that total, only 5 were chosen for the construction with the real pieces. Further to the main aspect of stability, refinement amongst the proposals was on the consistency of the documentation, correct calculation of weight forces paths, compression and tension elements in the structure, detail and appropriateness of connections and material exploration.

There was the subdivision of the students into five groups assigned to have leaders of the working teams the authors of the selected proposals.

Notes from the process observed pre-design approaches, formal composition, documentation methods and redesign strategies. A content exploration of the visual data (photos, drawings and models) generated by the students.

Factors of influence were isolated and characteristics associated with outcomes (stability, feasibility, redesign level, handleability and formal exploration) were compared with characteristics related to design process and decisions.

VI. Results

The greatest outcomes were accomplished with designs documented through hand drawings or CAD drawings finalised with hand drawing. The majority of the proposals CAD based had structural issues and had to suffer drastic adaptations for delivery of the models.

CAD representations imposed limitations to 3D thinking and detailing definition during design development. Pieces look as if to be perfect and identical and the functions copy and array deluded the novices about drawing precision. Details added manually seemed to increase the quality of the documentation and the final structure.

Results from this study shown that the use of digital tools during design had not improved the quality of the projects, as some functions conveyed to the reasoning they were working with identical pieces when designing, which caused issues when manufacturing the real pieces. The facilities of tool caused the disregard of essential material detailing.

VII. Conclusion

There are numerous methodologies for material selection in engineering design. However, there is a lack in the literature about methods for analysing material to be potentially upcycled. This research gap shows a need for a further constructive investigation to clarify how to adapt the practice to the new requirements, advances and tools and becomes more structured and rational rather than remaining randomly and experienced-based activity. The sensibility of the craftsman needs to be addressed to the convenience of digital tooling solutions.

This study explores initial factors to address when building knowledge linked to digital craft with reclaimed components. Followed by the appropriateness of tools and technique, materials learning and the proper input of information are the central aspects of reducing risks within the process.

As a new approach for design research, design for upcycling concepts requires further understanding and knowledge only will be built throughout consecutive research development. This initial study focuses on novice designers and aimed at establishing primary factors to address. However, final conclusions may only be possible by re addressing these initial findings and analyzing information from design practices performed by designers of different levels of skill and experience.

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