Is digitally-modelled rematerial practice a feasible response to Australian construction industry waste?

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Contents

Abstract

This thesis provides the rationale, methods and results of a research project that investigated the hypothesis that digitally-modelled, circular 'rematerial' practice (incorporating used components into a design) is one feasible response to Australia's problem of excessive construction waste landfill. A thorough literature review established that: 1) materials reuse is far more effective environmentally than recycling, and 2) rematerial design practices need to be embedded within digital modelling workflow to effectively reduce the volume, and increase the value of 'waste'. The thesis demonstrates, via case study analysis of 24 rematerial projects, industry surveys and reflective practice, that digitally-modelled rematerial practice in the Australian context can be practically achievable, financially feasible and meet design objectives. Survey results demonstrated that despite uncertainty regarding its financial viability, digital modelling of used components is already practiced. The analysis suggested financial uncertainty is fuelled by lack of industry information about methods. Reflective work on the researchers' own practice indicated industry professionals perceive modelling times to be far in excess of what can be achieved, providing opportunity for clarifying uncertainty and generating wider uptake. Ultimately, the thesis argues the barrier to rematerial practice is the lack of standardised practice frameworks, education, digital infrastructure, and policy and regulatory support to give compliance confidence and assign the appropriate economic and ecological value. These gaps burden individual designers, builders and clients with risk management in a policy void. With systemic support for rematerial practice, designers could have much greater impact reducing construction waste.

Introduction

In 2018/19 the Australian Bureau of Statistics (ABS) identified the construction sector as the second-highest waste-generating sector in Australia (ABS 2020), contributing 40% of landfill waste (Doust, Battista & Rundle 2021), thereby giving cause to examine waste-reduction strategies.

This thesis proposes a response to the problem of excessive construction waste landfill, namely, to promote the practice of digital modelling of used materials and objects in order to increase their specification[1], and thus increase use of used materials at the construction stage, thereby reducing waste. Ideally, the digital modelling would come with at least basic Building Information Modelling (BIM)[2] data.

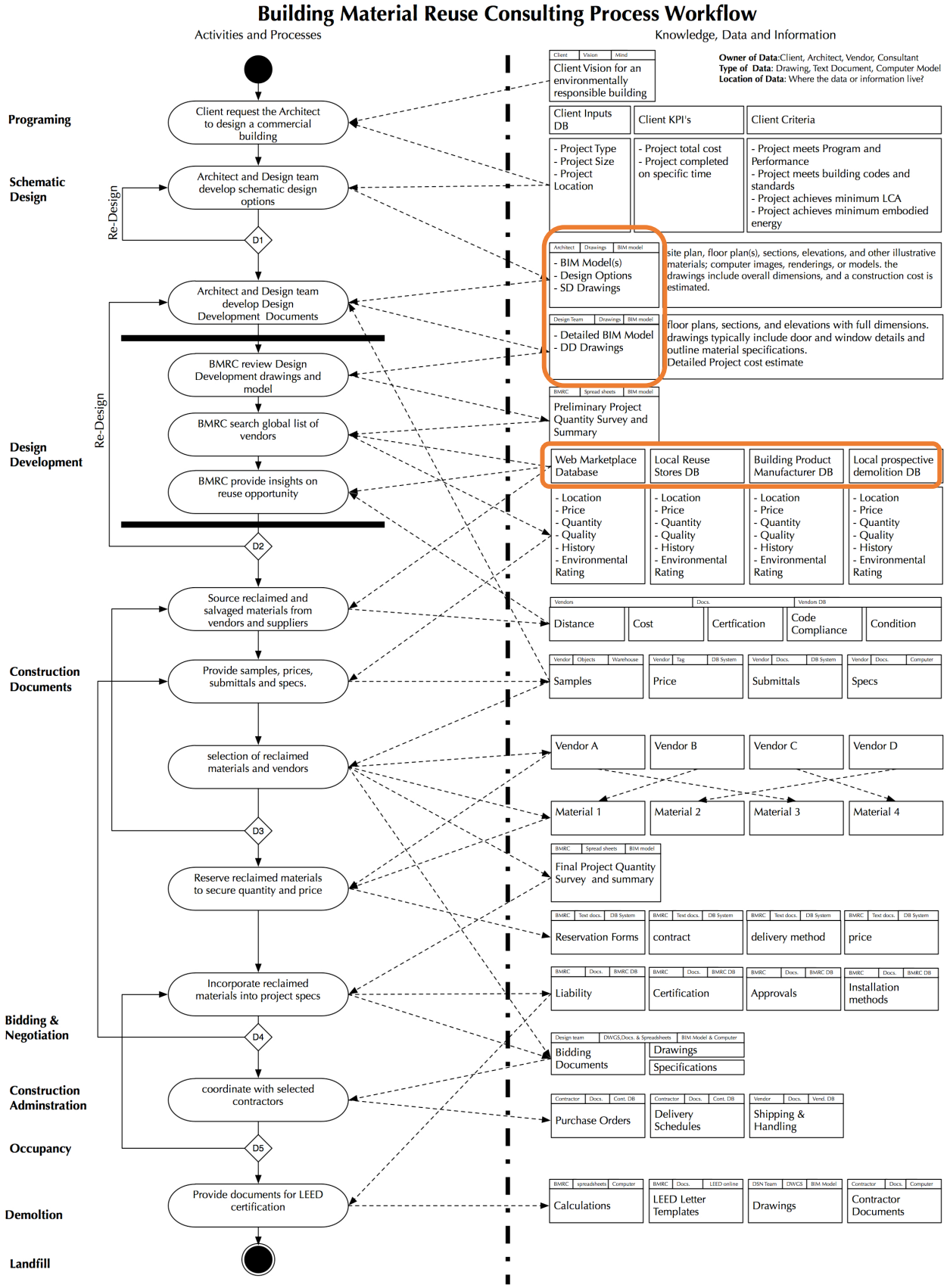
This thesis builds on the work of Ali (2016; 2019) by drawing attention to, and demystifying, the digital modelling work required to design with used components. The moments when digital modelling of used components can "be part of the design process from the start" (circled in Figure 1, Ali 2019, p. 16) (Kaza et al. 2018, p. 120) are the focus of this thesis.

[1] 'Specification' is a design task to select a particular item or material for inclusion in a project.

[2] 3D BIM objects of items (a digital likeness of the physical item), can be created as a visual-only output. Designers can use BIM to go one step further and include physical and functional information regarding the item, for example, wattage, weight, year of manufacture and so on.

Figure 1

The opportunities in Ali (2019, p.16)'s Building Material Reuse Consulting Workflow for digital models of used items to increase specification of these components



The design sector has had an "interest in ecology, sustainability, recycling, and product obsolescence" for decades (Blauvelt 2011, p. 171; Ellison 1978). This interest is now expressed in "the 3R's" (reduce, reuse and recycle), (Fang 2020), "reverse logistics" (Liang & Lee 2018) and "circular design methods" (Celadyn 2019a, p. 1).

Rematerial[3] practice is a circular "design [method] that *reuses* things and materials" in the final design (Appelgren, 2019, emphasis added).

Despite the prominence of recycling in public discourse and policy, it achieves far less effective environmental results than reusing materials. The US Environmental Protection Agency (EPA) demonstrated reuse "can generate energy and greenhouse gas emissions savings *of over 60% greater than recycling*" (Gorgolewski 2017, p. 263). At this time however, rematerial work is not practiced at scale, primarily due to cultural and systemic barriers (Ali 2019; Schambelan 2008). This thesis continues examination of "resourcefulness and wastefulness in production, the life cycles of products, and the role of use and consumption" (Blauvelt 2011, p. 171), in particular, by considering how rematerial practice can scale up economically via used materials trading systems *that include* digital/BIM models of the used components[4].

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[3] Appelgren (2019) is an important figure in the rematerial sector as an early author on the practice. Appelgren referred to the work as "redesign", however the author found readers were confused by this term due to its close association with the design activity 'redesigning a room' - which does not necessarily involve materials reuse. The author then referred to the work as 'bespoke reuse', but one survey respondent pointed out that 'bespoke' would not seem to include standard building materials that can also be reused such as standard steel elements. The author subsequently found the term 'rematerial' being used to describe the practice, and has thus adopted this term in line with other authors (Bahamon & Sanjines 2008).

[4] This term is used for brevity to refer to both materials and objects, both structural and decorative that comprise a building interior and exterior.

This thesis contributes:

1. A quantitative understanding of rematerial work as 'good design', validating it as a design practice worth investigating.
2. An understanding of why circular economy waste/materials trading platforms need digital models of used components to facilitate and grow market access by designers.
3. Digital modelling processes for rematerial work that have been validated at a small scale by the Australian construction design industry.

The first section of this thesis outlines the existing states of both Australia's construction waste, and the zeitgeist of the design sector that this proposed practice would inhabit; design aesthetics, digital modelling practice, financial concerns, social responsibilities and policy. This leads into description of the research question, then the methodology and methods used to research the question. The results are presented, followed by discussion of whether rematerial practice is desirable from a design perspective, and if so, whether it is practically achievable in an Australian context, and if so, whether it is economically feasible in an Australian context.

24 examples of rematerial work from around the world are semantically and semiotically analysed to examine whether they meet common design goals specified in literature. A small cross-section of the Australian construction design sector offers opinion, via anonymous online survey, on the practical and economic feasibility of digitally modelling used components. The authors' own self-reflective practice contributes to the data and discussion. These methods of analysis arrive in concert at a final speculation that digitally-modelled rematerial work *would* be feasible in Australia, especially if connected to a digitally-modelled circular waste/materials trading system.

Why this thesis?

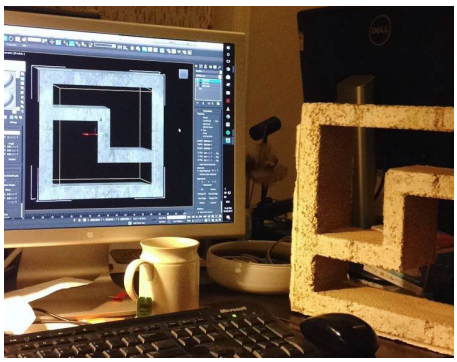
The author comes to this inquiry through experience working as an Assistant Project Manager with a small Adelaide-based company, P6 Projects, whose services include construction with used components as well as their Detailed Demolition service that encourages reuse at the demolition stage. The author has also worked with Fireside Architecture, who are led by Damien Chwalisz, an architect that has designed and built multiple successful commercial and residential rematerial projects[5].

Figure 2 demonstrates how digital modelling of used materials has played a role in the above work from design through construction phases.

Through these experiences, the author practically and administratively encountered the demands and processes of design, procurement, construction, demolition and waste

Figure 2

Snapshot of the role of digital modelling in achieving built outcomes with reused materials (rematerial work)



Author's digital modelling process of used component to be incorporated

Authors' digital visualisation of the rematerial design

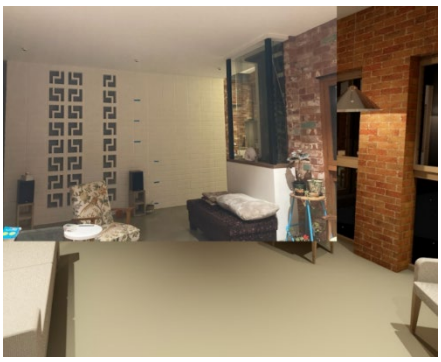


Image of constructed space layered over digital visualisation

[5] Examples: Kimbolton Wines cellar door www.fireside.net.au/kimbolton-wines, Mt Lofty Ruin House www.fireside.net.au/mt-lofty-ruin-house, Green Street House www.instagram.com/p/BID-4y_j_gc/

management that are currently undertaken in Australia in ways that generate large volumes of waste. The researcher witnessed this waste as at worst arrogant, and at best unnecessary and resolvable, thus choosing to explore how it can be reduced.

Literature Review:

Component reuse within the

Australian construction design sector

Environmental Context

In 2018/19, the construction sector was the second-highest waste-generating sector in Australia (ABS 2020), contributing 40% of Australia's landfill waste (Doust, Battista & Rundle 2021) and contributing to the export of 4.25 million tonnes of waste offshore in the last financial year (Pickin 2021, p. 1). Waste-reduction strategies are therefore necessary.

It is particularly incumbent on the interior design sector to play a role in reducing this waste burden, as while buildings are only fully demolished once, the interiors of buildings can undergo "multiple refurbishments" and therefore contribute multiple times to waste output (Celadyn 2019b, p. 106; Ying 2018, p. 24).

National and international policy recognise that reuse is a far superior environmental strategy than recycling (Lasani 2016, p. 12; Pickin et al. 2020; Rose & Stegemann 2018). Supported by Xing, Kim and Ness (2020, p. 1), Akanbi et al. explain why reuse is "more beneficial… because materials reuse requires minimal energy usage compared to the energy

needed for material recycling" (2018, p. 175). Rose and Stegemann (2018) warn that recycling processes can have "considerable" and "highly wasteful" negative environmental impacts. Specific material examples in the literature include; the recycling of steel, described as "highly energy intensive", with BlueScope Steel themselves citing reuse as "the ultimate" waste management strategy (Swift et al. 2015, p. 253); tyre reuse is "superior to alternative recycling strategies" (Ecoflex Australia cited in Chiveralls 2018, p. 214); and aluminium can and glass bottle reuse producing "considerably greater" benefits than recycling (Gorgolewski 2017, p. 27). Reuse also avoids some of the packaging that comes with new items, which is important because "packaging is the single largest category of plastic production" (with new construction industry products being the next largest category) (Liboiron 2018, p. 2).

While the concept of reuse is "embedded in [Australian] state and territory policy frameworks" (Lasani 2016, p. 12), the European Commission Waste Framework Directive (Rose & Stegemann 2018) and the U.S. EPA (Pickin et al. 2020, p. 20), as the second-most preferable waste management strategy - below decreasing waste output ('reduce'), and above recycling - only 11.6% of Australia's waste in 2019 was *available* to reuse (ABS 2020). "Waste minimisation through [the circular economy practice of] waste trading… has not received much consideration in the C&D waste sector" (Ratnasabapathy et al. 2021, p. 560). This could partially be explained by embodied energy in used items not forming part of the Australian energy recovery equation (Pickin et al. 2020, p. 24). This strongly positive evidence exists for reuse, yet the overwhelming majority of actions and investments in Australia are toward recycling.

'Sustainable interior design' literature continues to focus on recycling rather than reuse (Gale 2011, pp. 24-25; Lasani 2016, p. 102). At best, reuse practices are presented as one of a range of equal options to choose from (rather than as superior environmentally)

(Rashdan & Ashour 2017; SarjooPatel et al. 2015, p. 3; Shooshtarian et al. 2020, pp. 223-225; Vakili-Ardebili & Boussabaine 2007, p. 91) and at worst are listed with an implied or explicit caveat that "reuse is often considered unaesthetic" (Alfuraty 2020, p. 8) or sub-standard (Appelgren 2020, p. 6; Chesaro 2020, p. 83; Gorgolewski 2017, p. 255; Xing, Kim & Ness 2020, p. 17), but most often, simply omitted, as if reuse was never *really* an option (Akinade et al. 2018, p. 381; Chesaro 2020, p. 82; Coleman 2017, p. 90; Gale 2011, p. 24). For example, Hayles' 2015 paper on supply of and demand for green, sustainable or Fair Trade products for interior design does not list used items as an option. More broadly, a 2017 literature review by Akanbi et al. (2018, p. 176) found that *no sustainability assessment tool* provided a measure of salvage/reusability value.

The 2021 Circularity Gap report presents the opportunity: "In providing Housing… 82% of [potential, achievable] emission reductions are related to the material side—the supply chain of construction materials" (Circularity Gap Reporting Initiative 2021, p.42).

Design Context

The researcher argues that the aesthetic beauty of the beams in Figure 3 is deepened by knowing their forms and tones were shaped in their former century-long life as elements of a wharf. Certainly, the client, who lived in the region of the historic wharf, felt that way; participating in "the religion of patina" (Le Corbusier 1987, p. 152); "the dimension of the sacred" (Harries 1998, p. 290); willing to pay more for the treasure and their careful installation, than to have fresh, anonymous, "'low cost'…'bare life'" beams installed (Agamben cited in Zaera-Polo 2011, 112)[6].

Figure 3

Rematerial renovation by Fireside Architecture and P6 Projects incorporating wharf timbers.

Image credit: Roxane Adams

[6] The author knows this willingness anecdotally as the Assistant Project Manager for that project.

However, in terms of academic debate, rematerial work has almost exclusively been published in environmentally-focused journals. It is not the focus of these journals to represent the understanding that a relationship to materials and objects is deepened, attachment strengthened, and value increased, when one knows and feels connection to the cultural or historic past of an item. These journals focus on environment rather than design merit. The limited work that has been done to incorporate used items into value/sustainability-measuring tools has valued used items "in terms of quantity", omitting aesthetic, historic, cultural or social value (Akanbi et al. 2018, p. 176), and appearing in the construction process - after the design phase (Akinade et al. 2018, p. 376) - thereby systematically excluding designers[7] from participating in value discussions. This thesis begins to fill this gap by examining rematerial projects for outcomes aligned to *design* core business; that account for the textural and evocative nature of used objects (Chau 2018 p. 118; Josefsson & Thuvander 2020, p. 5) and their social and historic characteristics (Butler 2018, p. 53; Crocker & Chiveralls 2018).

Client "request" for or against reused components or sustainable design is said to strongly influence designers' uptake of these practices (Templeton 2011, pp. 127-29). It is not new however, that through "fashions, the publication of books, and the assiduous efforts of… decorators,… clientele… [are] awakened" and re-awakened to aesthetic directions (Le Corbusier 1987, p.150). Multiple authors have therefore argued that designers have a responsibility to invert this drive format (Elrokhsy 2013), and champion an "ecological

[7] In this thesis, 'designer' is used to refer to anyone undertaking recognised design practices. They may have no formal training, or accredited leaders in their field. The professional backgrounds of the survey respondents in this thesis represent those I am broadly referring to as designers: set designer, museum curator, architect, interior designer and building designer.

aesthetic" (Ali 2019; Boehneret 2011, p. 37), assuring clients of the value and integrity of these design moves, or at the very least, their "economic equivalence" (Liboiron 2018, p. 43). This moment, when a designer chooses to incorporate used components at the design stage; sees them as "architectural value actors" (Allen & Shakantu 2016, p. 925; Swift et al. 2015, p. 259; Vakili-Ardebili & Boussabaine 2007, p. 90) is critical to amplifying rematerial's value as an outcome. This research therefore asked designers from a cross-section of disciplines for their perspectives on the decision to use used components and their digital design process. 24 rematerial projects were analysed against design objectives; to "enhance quality of life and culture of the occupants"; to be "aesthetically attractive" (Abd Hamid et al. 2017, p. 2); create "atmosphere" (Sloane 2014); meet "functionality objectives"; and contribute to occupant "pleasure" (Pearce 2018, pp. 1,8) and "wellbeing" (Petermans & Pohlmeyer 2014).

Digital design and Building Information Modelling (BIM)

The interior design sector now firmly operates within the realm of the virtual; from Ikea to Bunnings, to boutique architectural practices, customers now expect to be presented with a digital likeness of the work they are to have done. Moreover, Building Information Modelling (BIM) provides "a digital representation of physical and functional characteristics" (Joblot et al. 2017, p. 10518) that goes beyond visual representation by also including the storage of data, eg. paint finish, lumen output, manufacturer and so on. 3D modelling and BIM proficiency is now an assumed interior/architecture graduate skill, and a skill development focus area for the Australian government (Abd Hamid et al. 2017, p. 2; Australian Industry and Skills Committee 2020; Akinade et al. 2018, p. 377; Allen & Shakantu 2016, p. 923; Artibus 2020, pp. 70,73; Asojo 2012, p. 144).

In the last five years, there has been a proliferation of manufacturers and traders[8] providing digital BIM versions of their products (referred to as 'BIM objects'); understanding that the digital design process is a key specification (sales) moment (Bidewell 2016). "Architects and designers [now] *rely* on manufacturers to create BIM objects" (Bidewell 2016, emphasis added) as they remove their own modelling time/cost. BIM objects for used architectural components are not currently available to Australian designers. The significance of this, is that if used materials are not documented in at the design stage, it becomes difficult to incorporate these used elements later at the construction stage, because client permission needs to be given, engineering assured, dimensions accurate, supply assured, building codes considered, and so on.

Acceptance of the centrality of digital design has prompted work to provide digital models and frameworks to catalogue and sell used *structural* building materials via online market trading sites (McGinley 2015; Swift et al. 2015; Xing, Kim & Ness 2020). These 'trading platform' websites coordinate the sales of used items from multiple physical sites (eg. salvage yards), thereby increasing the range available to consumers. Less-available, but still progressing, is online trading of used *non*-structural elements such as windows, furnishings, fittings, textiles and objects; a primary component of interior refurbishment waste.

Akanbi et al. assert that "genuine innovation within the construction industry *must* be BIM compliant" (2018, p. 178, emphasis added), yet "most of the existing waste management tools are not… [which is] a huge gap" (Akinade et al. 2018, pp. 82,376; Joblot et al. 2017, p. 10522; Xing, Kim & Ness 2020, p. 6). Chong, Lee and Wang identify there has been "little

[8] eg. Caroma, Reece, Beaumont Tiles, BIMObject, ArchiProducts, Fielders, Stramit, Haws Corporation, NBS, Silestone, Schiavello, BIM&Co

work" on how BIM "could be applied in refurbishment" (2017, p. 4121). Ajayi et al. (2015) add that waste tools also need to integrate with design tools.

The review of literature indicates there is no extant model for how to digitise used components in a time/cost efficient manner to increase the usefulness of these sites to designers. The lack of a clear process - and any differences to standard modelling - may support a sense of impossibility and unidentifiable expense surrounding this aspect of rematerial work.

There are, however, trials progressing these matters. Akanbi et al. (2018) have trialled a BIM-based design-stage whole-life assessment tool, material banks and passport systems are being trialled (Rose & Stegemann 2018, p. 4), as are BIM tools for sustainable specification (McGinley 2015; Swift et al. 2015; Xing, Kim & Ness 2020). There is design for "choosing [used] materials and components" (Gorgolewski 2017, p. 273). Xing, Kim and Ness (2020, p. 3), and Rose and Stegemann (2018, pp. 4,5) suggest components with high reuse potential. Abu Bakar Abd and Mohamed Rashid have listed BIM activities interior designers perform generally (2016, p. 3). Sustainable design processes have been put forward by Lee (2014), Appelgren (2019, 2020), Celadyn (2018) and Ali (2019, p.16), and whilst Ali's process (Figure 1) is specifically focused on materials reuse, it does not expand on digital modelling practice.

This thesis therefore documents digital modelling processes for rematerial work (Figure 11), and the Australian design sectors' response to these processes.

The articulation of digital modelling processes for used components expands the roadmap for designers to choose rematerial work by demystifying, quantifying and clarifying the process and its value as an outcome.

Budgetary Considerations

In addition to a lack of design discussion (versus environmental), risks in terms of aesthetics, supply, timing, ROI and warranties have been levelled against rematerial work (Gorgolewski 2017, p. 259; Joblot et al. 2017, p. 10521). The "uncertainty of renovation projects" impacting process planning (Joblot et al. 2017, p. 10520) including procurement (Aguiar Costa & Grilo 2015) is multiplied by "the trouble", "uncertainty and risk" that incorporating used components is said to bring to projects (Appelgren 2019, p. 4; 2020, p. 65). Risks are almost always equated to a budget line. However, Manzini (2011, p. 59) inverts this suggestion of risk from used materials, convincingly arguing that rematerial designs create "non-homologous designs" that therefore *spread* risk. To illustrate, if you have designed a series of townhouses with the same cladding, then a supply shortage will be a significant issue. Whereas, if a mix of complimentary claddings are specified, the supply risk is decreased. Rematerial *design* often tessellates and/or divides surfaces, and combines complimentary materials, so that long runs or large single uniform quantities aren't relied upon, reducing the supply risk further (see Figures 3 and 39).

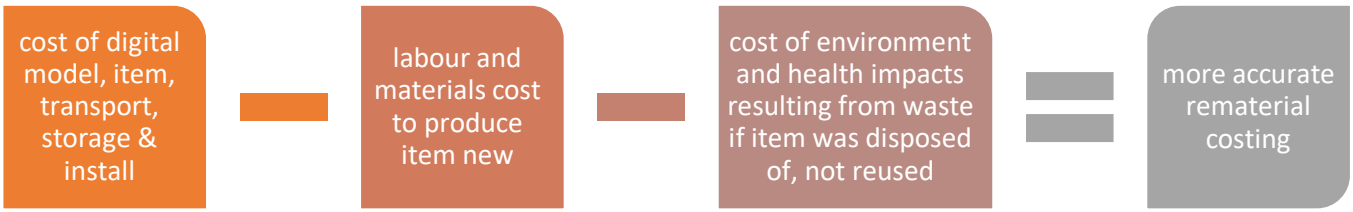
The perceived and actual financial feasibility of digitally-modelled rematerial work would seem to rest with five cost elements:

1. digital modelling,
2. the cost of the used items themselves,
3. transport,
4. storage,
5. install costs.

These budget lines belie the larger financial, health, social and cultural costs and benefits that design projects generate, and further still, the costs of *not* practicing rematerial work. To appropriately assess whether digital rematerial design is economically feasible, the hidden systemic costs need to be accounted and budgeted for, such as the resource waste and labour cost saved by not newly creating an item, and waste costs that would otherwise be incurred in not reusing the items, including environmental. Figure 4 distills this into an equation:

Figure 4

Visual representation of rematerial costs, version 1.



Whilst this is presently unusual accounting practice, there is emerging agreement that "the global market at present does not properly account for or price" materials, for example where "the producer does not bear the full costs of production (which includes… pollution)", or where – as is rife – a 'future interests' value is not applied to products to account for the impact current products will have on future generations (Crocker et al. 2018, p. 1, 41, 44).

Anecdotally, there is an expectation within the building sector that used goods should be sold at below retail cost of the equivalent new item. In many cases this is reasonable, if the material is sourced at low cost to the supplier, and if it closely approximates the item when it is new. However, the antiques industry attests to the increased value of some used materials. When the wearing of time and activity *affords* the material or object greater value (as illustrated by Figure 3), not only should we not be fearful of clients paying for this value,

but this is *precisely* what makes rematerial practice such a beautiful, rich design direction. Used materials and objects are not 'seconds.' It is the very *nature* of being used that *makes* them valuable – often more valuable than 'the new' through their exclusivity.

When designers attempt to evoke an alternate time, place, feeling or sensation, for that space to be constructed, at least partially, from materials or objects that are either *of* the time, place, feeling or sensation sought, or evoke such, is fast-tracked via the use of used items steeped in these experiences - even if only through repeated anecdote such as *"did you know that chair belonged to . . ."*. Wang's Ningbo History Museum (Figure 5) is a fine example of this, wherein the replacement of the cladding with any other material than those specific used tiles, would render the project potentially still beautiful, but without the deep meaning that "can arouse collective memory" and *connects* and draws visitors to the museum (Chau 2015, p. 362).

Figure 6

Visual representation of rematerial costs, version 2.

Figure 5

Ningbo Historic Museum, by Wang Shu, Amateur Architecture Studio, 2008
Image credit: Photo by Iwan Baan.

The rematerial financial equation thus expands to:

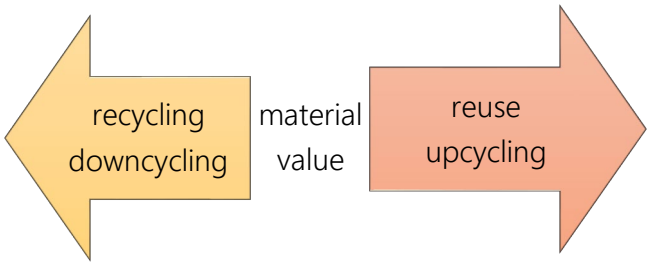
To conclude on budget matters, the literature demonstrates recycling of materials is not as beneficial as the public is led to assume. When materials are recycled into new products for use, these processes create a loss of material integrity and/or value (known as 'downcycling'), and can generate their own waste to add to the problem (Pickin et al. 2020, p.

15). 'Upcycling' is when the *value* of 'waste' is increased; an entirely different focus to quantity-reduction (Rose & Stegemann 2018, p. 5).

Social and Policy Context

Figure 7

The economic impact of reuse vs recycling



The lack of investment in exploring risks posed by rematerial work, and the reason for prioritising recycling over reuse, is perhaps explained by the distortion of circular economic models to fit the present competition- and scarcity-based linear economy; invisibilising the abundance of materials that already exist for reuse (Zwier et al. 2015, p. 358), and the need to simply stop producing 'more' (Valenzuela & Boehm 2017; Appelgren 2019; Veenis 1999).

The entwining of policy with social values becomes evident where policy supports "the social construction of needs" (Zittel 2021) and the "manufactured scarcity of materials" (Till & Schneider 2011, p. 43) by not enforcing limits on the creation/use of new materials/objects when there are used versions that could do the same job. Chesaro puts it plainly: "contractual provisions for …maximization of materials reuse… could significantly reduce waste generation" (2020, p. 60). Policy-makers need to champion the requirement for materials reuse as part of the suite of 'green' options, and advocate for systemic initiatives to support this, such as digitally-modelled used materials marketplaces.

Research Question

This research addresses the primary research question: Is digitally-modelled rematerial practice a feasible response to Australian construction industry waste?

This primary question is broken down into three sub-questions:

1. Is it worth doing? ie. Have rematerial projects met design goals:
    a. to "enhance quality of life and culture of occupants";
    b. to be "aesthetically attractive" (Abd Hamid et al. 2017, p. 2);
    c. to create "atmosphere" (Sloane 2014);
    d. to meet "functionality objectives";
    e. and to contribute to occupant "pleasure" (Pearce 2018, pp. 1,8) and "wellbeing" (Petermans & Pohlmeyer 2014)
2. Is it practically feasible? ie. Do Australian designers view Figure 11 (an initial model presenting practices for digitally modelling used items), as practically feasible?
3. Is it economically affordable in the Australian context?

Methodology

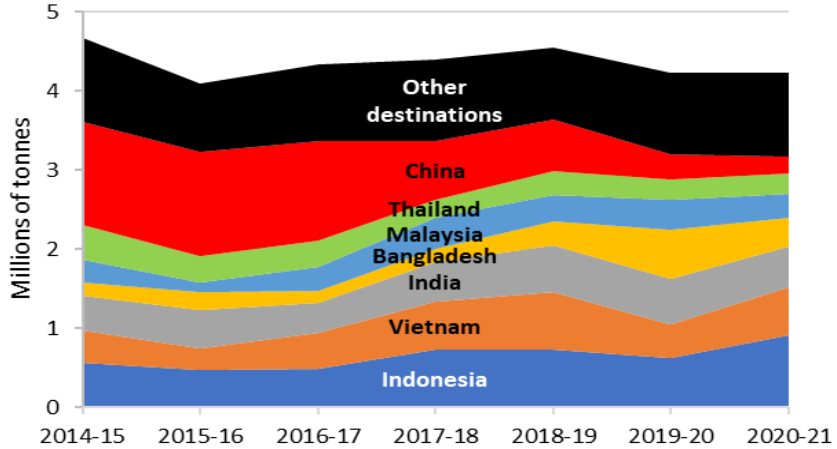
The methodology for this thesis is developed from the interaction of feminist theory and Actor Network theory. Feminist theory provides an ethical platform through which to engage with the West's obligation to the effects of its waste on often silenced and hidden (offshore) people. Actor Network Theory (ANT) provides a conceptual frame through which to resist reductionist explanation of rematerial practices and maintain the complexities of actors, relationships and agencies enacted through rematerial practice.

'Good' environmental response to construction waste means very different things across the large global economic divides that exist (Fuller 2010; Guy 2005), and therefore a feminist framework advises 'locating' discussion of solutions such as rematerial practice. This thesis emerges from my specific Western cultural context[9] (Groat & Wang 2013).

Within the West, human (most especially offshore) labour is easily removed, hidden or even worse, forgotten, from the economic equation of design and construction work (Appelgren 2020, p. 69; Valenzuela & Boehm 2017, pp. 24-26; Zwier et al. 2015). But the Wests' production of the new, and waste from the 'old', are "elegant… forms of disaster" (Fry 2011, p. 27) representing "silent testimonies of the life of the poor and exploited" (Veenis 1999, p. 157) who are burdened with enormous - deadly[10] - health, wealth and lifestyle impacts as a result of Western consumption cycles (Appelgren 2019, p. 2).

Figure 8

Exports of waste from Australia by financial year, showing the top seven destinations



[9] see section 'Why This Thesis?'

[10] England, Rachel. 2017. "Living in Landfill." In.: The Independent UK. Accessed at www.independent.co.uk/news/long_reads/living-landfill-a7632996.html

Desire, consumption, development and production have a social context and consequence; "ways of being are tied up in obligation" (Liboiron 2018, p. 1), whether taken up or not. 64 million people are impacted daily, *15 million* of whom *live in* rubbish tips around the globe, and can expect, on average, to die at 35 years of age (England 2017). These 'rubbish towns' are 'built' from "over 90% of the globes' waste [being] openly dumped or burned in low-income countries" (Ijjasz-Vasquez 2018).

Figure 9

Child 'waste pickers' in Cambodia. Image credit: Geddy Images in The Independent UK (England, 2017).

If the "ethical function [of the designer] … beckons us toward a better life", then that better life should extend to those directly impacted through our design, construction and consumption (Fry 2011). Moreover, this impact must be included in Western economic equations. If there is no "I" without relation (Butler 2001, p. 8), then there is no ethical designer without recognition of the full supply chain (Crocker 2017, p. 2).

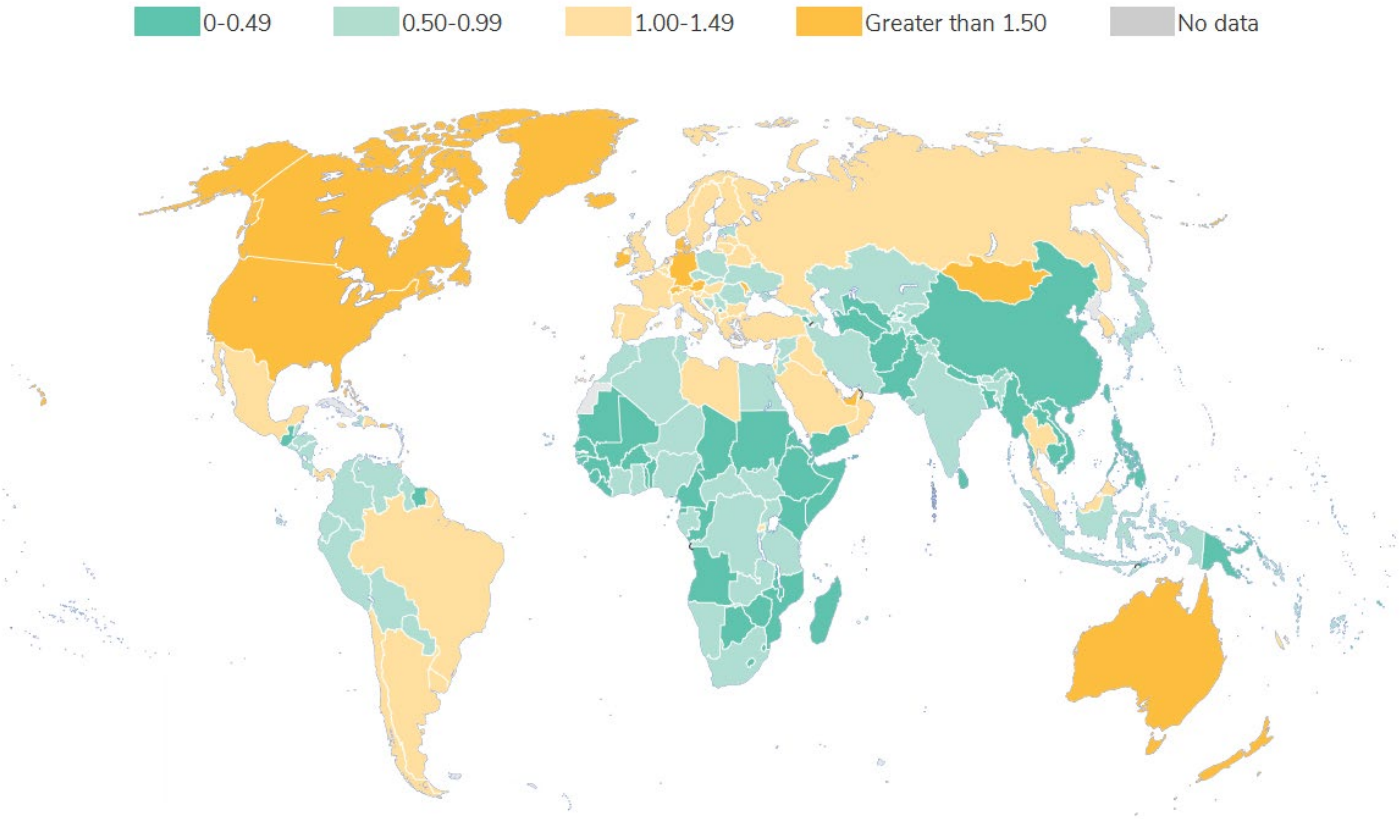
Whilst there is an emerging milieu of recognition that Western design, architecture and building sectors are obliged to the environment and peoples it impacts[11], and the methodology of this thesis is radically motivated by the plight of the people impacted by Western design, production and waste, it would be self-congratulatory to suggest the methodology is design activism, wherein it is asked "Are we doing enough as a profession to address the critical challenges of our time?" (University of Washington 2021). *Cleaning up after oneself*, or honouring industrial rights, is not a critical challenge, but basic industrial and interpersonal responsibilities. La paperson (cited in Liboiron 2021) appropriately calls out the practice of "gathering… 'natural' resources as assets but also externalizing the 'cost' of the accumulation in the form of contaminated water, disease, and other traumas [as] primitive". Positioning this work that considers 'the Other' as activism suggests that it is optionally available to be undertaken by those with enough care and energy. This is not the case. This is basic, fundamental and mainstream responsibility, and should politically be attended to as such. Our methods of practice *are* our ethics (Liboiron 2021). This position forms the methodological foundation of this thesis, its reason for being. The author is 'obliged'.

[11] See projects such as the Waste Age: What can design do? Exhibition https://www.ribaj.com/culture/peak-waste-what-can-design-do-review-design-museum, Architects' Climate Action Network www.architectscan.org/, the Design as Activism website https://designactivism.be.uw.edu/, and Design Can: https://design-can.com/,

The methodology is aligned to Jenkin's feminist-based work with men who use violence (Jenkins 1990); an invitation to take responsibility; to choose non-violence to the environment and people affected by our waste practices. It is to agree with Fry that "the essence of structural unsustainability is 'us'" (2011, p.42), and the World Bank's waste generation data map below (Kaza et al. 2018, p. 19) clarifies that Australians are well and truly within the "us" category:

Figure 10

World Bank Annual municipal solid waste generated per capita (kilograms/capita/day)



Not considering the people whose lives are impacted by our waste can only be construed as a politically-endorsed rejection of the value of those *lives* (Agamben in Fry 2011, p. 31). Instead, this thesis attempts to promote Fry's three qualities of 'sustainment':

1. *The creation of, and movement to, a new economic paradigm that abandons the notion of continual growth.*
2. *The retrofitting of the material world… (…currently obscured by the ongoing creation of ever more things, including 'green things'…)*
3. *Recognition that structural unsustainability is an ontology…*

(Fry 2011, p. 23)

The influence of Actor Network theory (ANT) to pay attention to "interconnections, relations and co-constructions [is] well suited to the study of… environmental problems" (Murdoch 2001, pp. 113, 120). It complements the feminist approach, also contributing a "'relational ethics', one which emphasises 'the situatedness of ethical agency and the extralinguistic connectivities'" (Whatmore cited in Murdoch 2001, p. 128). Australia's waste problem is a practically, economically, spatially and ethically complex ecosystem; wicked (Rittel & Webber 1973; Goel 2019) and "messy" existing in a "complexity… of 'networks'" (Murdoch 2001, p. 118), and therefore solutions need to be explored in an equally networked manner with the range of actors accounted for. This methodology includes inanimate objects and systems as actors. Rubbish not only animates human and environmental activity, but looms as a giant effecting being that cannot be tamed by governments. Economic and political systems insist that some people live, work and die young in rubbish environments. The digital realm and its expensive paraphernalia, as well as the earth itself, are also key actors within the ecosystem of desire, design, construction, consumption, demolition and waste practices that this thesis interrogates.

The web of approaches to reducing construction waste is enormous. Focusing on digital modelling of used components within this enormous field of possibility, emerges from

a perspective that a key moment of potential for Western construction waste reduction is in the moment of design specification. Akinade et al. agree "the best approach to CDW management is minimisation through design…" (2018, p. 383). Reuse is one such minimisation strategy.

Methods

The methods used for collecting data to test the hypothesis that digital/BIM-based rematerial practice *is* one effective response to Australia's problem of excessive construction waste to landfill, are outlined below. The term hypothesis is used in the way that Groat and Wang refer to 'theory'; "active contemplation" through "removed and systematic accounting" (2013, p. 74) that describes, explains and "predicts future behaviours" (2013, p. 78). The methods below were used to "draw logical coherence from both mathematical and discursive, cultural world views" (Groat & Wang 2013, p. 302-03) through quantitative and qualitative means.

Method 1: Case study analysis

Case study analysis - "an empirical inquiry that investigates a phenomenon" - is the primary method utilised across the three research sub-questions (Groat & Wang 2013, p. 346). Groat asserts there are five characteristics of case study analysis (cited in Groat & Wang 2013, p. 346). These are reflected in this thesis:

1. The case is studied in its real-life context (2013, p. 346); "in relation to the complex dynamics with which it intersects" (2013, p. 347).

2. The case can explain causal links; "uncover the multiple, complex and sometimes overlapping factors that eventually lead to particular outcomes" (2013, p. 349).

These first two characteristics are met through semantically analysing the designers' perspectives of the 'case', as well as publicly-available views about the case written by people other than the designer, ie. architecture publications, engineers, product supply, industry bodies, academics and funders (see Appendix 1: List of Case Study Projects and Corpora Sources). Differing interests in, and vantage points on the projects are thus included.

3. There is some level of knowing at the design stage what intention (theory development) the researcher has for undertaking the case study research (2013, p. 352). From the proposal stage, this thesis identified an intention to explore the 'feasibility' of rematerial work.
4. Case studies rely "on multiple sources of evidence, with data needing to converge in a triangulating fashion" (2013, p. 346). In this thesis, linguistic data is drawn from designers and non-designers and is triangulated with visual data.
5. The case operates instrumentally for the hypothesis (Stake cited in Groat & Wang 2013, p. 355), providing generalisability to theory, rather than being the main focus in and of themselves (Yin cited in Groat & Wang 2013, p. 354-55). The researcher sought to identify whether rematerial *practice* was feasible, not whether individual case studies were feasible. Through aggregation of practitioners' "direct and vicarious experience" (Stake 2009, p. 2) the cases provide generalizable insights, or elements of "transferability" (Lincoln & Guba cited in Hammersley, Foster & Gomm 2009, p. 3).

As rematerial practice is more established outside of Australia, case studies were selected from across the world, according to the following criteria:

- Cases needed to express an element of 'interiority' or an "an ambience, which is a space in and of itself" (McCarthy 2005, p. 121; Power 2016),
- Cases incorporate used components in the design
- Cases do not rely on hand-made structural materials, as this is not commonplace in current Australian construction
- Cases had been physically built
- The author does not have a pre-existing relationship with the designer

The case studies were selected by consulting a seminal text in the area: *Rematerial. From Waste to Architecture* (Bahamon & Sanjines 2008). 50% of projects were taken from this, then an internet-search pearling process from these projects led to other projects, architects and firms, making up the other 50% of case study projects.

25 case studies were initially included. For one of these, only text that was authored by the designing agency could be found, and therefore it was excluded from the final analysis. 24 case studies were analysed (listed in Appendix 1).

Semantic Case Study Analysis

Corpus linguistics is a non-observational method that analyses bodies of text - corpora - or "a set of language production samples designed to be representative… through careful selection – not randomly collected" (Nilsson Björkenstam 2013, p. 2). This method "conforms to standards commonly ascribed to 'the scientific method': falsifiability, completeness, simplicity, strength and objectivity" (Leech cited in Rayson 2008, p. 3).

Data-driven, concordance corpus linguistics (Rayson 2008, p. 3) has two key features; firstly, the analysis does not rely on the researcher's "intuition" (Stubbs cited in Rayson 2008, p. 10) or "prior selection of which linguistic features to study" (Rayson 2008, p. 4). Instead,

selection of what is of interest is generated by the data. In this research, the *direction* of analysis was known (the research questions), but *what to look for* was not.

Secondly, concordance analysis is "an extension to the key words procedure" (Rayson 2008, p. 14), as it detects *relationships* between words, as well as tagging and analysing part-of-speech and semantic fields, rather than solely individual words[12]. "Collecting together words into their semantic fields allows us to see trends that are invisible at the word level" (Rayson 2008, p. 39) and for these reasons this method does not exclude "articles (*the*), prepositions (*to, of in, for*, etc), conjunctions (*and*)" and other "high frequency words" from the corpora (Rayson 2008, p. 22).

Rayson's process (2008) involves automated analysis, though the corpora can be, and usually are, manually prepared, as they were in this case. The same software tool, Wmatrix, that Rayson used in his paper introducing this method (2008) was used to analyse the case studies. Wmatrix incorporates both USAS (UCREL Semantic Analysis System) and CLAWS part-of-speech tagger for English software. The USAS software tool automatically "annotates each word or multiword unit in a text with a semantic tag" (Lu 2014, p. 148). The Wmatrix software analyses the relationships between the tagged text, and against the BNC Sampler Corpus[13].

Corpus data was derived from 97 publicly-available web and print texts about the 24 rematerial projects (cases) that the researcher found within the timeframe (Appendix 1).

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[12] Some words may differ from one another, but have the same meaning and/or be part of the same semantic field. Some words change in meaning when they are collocated with another.

[13] The BNC Sampler Corpus is a subcorpus of the British National Corpus. It was chosen over the full BNC even though it is smaller, as it is tagged against 135 tags versus only 61 with the BNC, and there has been manual checking of the Sampler, "so that errors are minimal" (UCREL, 1998).

This corpus - corpus 1 - was tested for Bryant et al's 'Ontic Principle' (2011, p. 263); checking to see if there *were* any differences between corpus data from differing source types. If there were no differences, corpus 1 alone could be used for analysis.

Five corpora were created to "detect patterns and idiosyncrasies in people's practices and in… how they… represent themselves and the worlds they live in"; their "linguistic categories" (Pink 2015, p. 148).

Corpus 1. Published text found about the 24 case studies. This text is authored by both designers and non-designers. These form a representation of the published zeitgeist that readers are exposed to about rematerial practice as a whole.

Corpus 2. Only text from corpus 1 that was published by non-designers, for example industry awards sites and architectural magazines.

Corpus 3. Only text from corpus 1 that was published by the designers of the case studies, primarily on their agency websites.

Direct pasting of content from one website to another was not uncommon across architectural review sites[14] . This could be said to represent that these publishers agree with, or are happy to have the case studies represented in this way, under the name of their publication, hence it is suitable to analyse this text as both the linguistics of the designer, *and* the non-designer. An alternative reading is that this practice distorts the "linguistic categories" of the non-designers because they have published the words of the designers, not their own. Rayson (2018) settles this matter by advising it's "important that the two corpora do not overlap, or that one is not a sub-corpus of the other" therefore, the latter reading is taken.

[14] See Appendix 6 that visualizes examples of duplicated content.

Two further corpora were thus created for analysis.

Corpus 4. This is as per corpus 2 (published by non-designer), but with quotes of designers and pasted text from designers' publications removed, leaving only text *generated by* non-designers.

Corpus 5. As per corpus 3, but with quotes of, and text written by designers but published by non-designers, added.

Corpora 2 and 3 represent what the two groups are happy to have published under their name, whereas 4 and 5 represent only what that group actually wrote/said *themselves*; where they are "the "producer" of language" (Nilsson Björkenstam 2013, p. 2). The data published by the designers (Corpus 3), represents not only what designers have said, but in particular what they wish to promote and curate, and therefore represents most purely the cohorts' "linguistic categories" (Pink 2015, p. 148). Corpus 5 is all text authored by designers. This corpus 'waters down' or 'broadens out' corpus 3 by including not only the designers' curated text, but also what they have offered into the public milieu. This dialogue is skewed by what the designers have been *asked* to speak about by the non-designer authors, and therefore whilst genuine to the cohort, is not necessarily the cohort's prioritised interests (hence corpus 3 represents this better). Corpus 4 is text authored by non-designers. This corpus represents what non-designers are particularly interested in over-and-above the shared dialogue with designers.

Figures 53, 58 and 59 in Appendix 7 show marked differences between the corpora. Given this, corpora 3, 4 and 5 were analysed.

In preparation, the corpora were checked for spelling errors and to bring all language into linguistic alignment (eg. center and centre become centre) so that words that should be

counted together, were. The results of the corpora were normalised[15] and assessed for statistical significance (Rayson 2008, p. 23). Log-likelihood (LL) provides a value to represent the probability of observing a sample, in this case single words and semantic categories. For corpus linguistics, an LL of 15.13 is recommended as the minimum value to indicate statistical significance[16] (Rayson 2008, p. 23), and therefore only data with this LL or above was included.

Words the software could not match to a category, numbers and personal names were removed from the results.

Further to the software analysis, a manual review of the corpora was conducted to elicit evidence for achievement of the design goals articulated in the research question. The assessment criteria to assess achievement of these goals is included as Appendix 2, and the data gathered against the criteria is provided in Appendix 3.

The most difficult categories to analyse were aesthetic attractiveness, followed by pleasure and wellbeing, then quality of life and culture. These equate to the most subjectively, and therefore in this thesis conservatively, assessed items. If positive comments were only made by the designers, this was considered insufficient to be awarded the criteria. If only one positive comment was made by non-designers, the criteria was considered 'unsure'. This subjective process can thus only be used speculatively, but Appendix 3 provides the data/rationale that supports the researcher's decisions to nominate whether each project met design goals.

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[15] To normalise is to convert to a percentage rather than count; "relative frequency"

[16] Data with a log-likelihood (LL) value over 7 is ordinarily considered to be statistically significant (UCREL, nd.)

Semiotic case study analysis

Design is multisensorial, both in its creation and consumption, therefore, it is relevant to analyse "the embodied and sensuous character of the work" (Pink 2015, p.148), and what occupiers of these projects may have taken away sensorially, and folded into their remembered evaluation. "Memory functions multisensorially"; "touch and vision… share an experiential field" (Pink 2015, p. 145). Given touch is beyond the capacity of this research, images within the case study publications were analysed.

All images published within the corpora publications were collated. This included duplicates as taken together, represented the visual landscape of published rematerial work. Most images/publications were online, however where in print only, photos were taken of the print documents and included. In total, 1,105 images were collected. Due to brevity of time, the entire photographic collection was not analysed, rather, the visual corpus comprised six images from each project – where available – two exterior, two interior, one of the digital model and one detail image. 99 case study images were analysed comprising 9% of all images collected.

The semiotic analysis sought to understand if rematerial work could be considered quality aesthetic design based on whether these projects visually reflected the generally-accepted architectural zeitgeist. The online tools Google Images and Pinterest were used to locate images similar to each corpus case study image in architectural style, materials choice and image composition, but from a non-case study architectural project. Where a similar image was unable to be found, a white image was inserted to signify this.

Method 2: Community consensus surveys on rematerial practice and digitally modelling used components

Groat and Wang argue that "agreement from the community [that the hypothesis] … is directed toward is… a logical imperative" (2013, p. 84). For this reason, two online anonymous surveys were distributed to seek industry agreement or otherwise, on the hypothesis broadly (the viability of rematerial work), and on Figure 11 below; methods of practice proposed by the author in relation to modelling used components.

All respondents were given a unique identifier: their role (A=architect, ID=interior designer, L=landscape architect, SED=set/exhibition designer, BD=building designer, AID=architect and interior designer), then the length of time they'd been in the role (eg. >5 represents greater than 5 years), then a letter as the unique identifier. Survey one respondents have an additional identifier at the front of their code: *Int.*

Survey Distribution

The surveys (Appendix 4) were promoted via direct email invitation and administered via a web page/form[17]. All questions were visible at once for participants to assess the differences/nuances between questions if necessary.

Survey One was emailed to 20 of the designers of the analysed case studies, for whom the researcher was able to locate an email address, with one follow-up email.

Survey Two was emailed to 18 Australian industry organisations, with a request that they forward the survey to their contacts. Invitations to participate were also sent directly to

[17] https://thisisradas.com/survey1 and https://thisisradas.com/survey2

designers via 563 email addresses sourced from publicly-available designer lists accessed via industry bodies including Australian Building Sustainability Association, Australian Institute of Architects, Building Designers Association of Australia, Design Institute of Australia, Guildhouse, Houzz, Interior Design Association and Universal Design Australia. This cohort also received a follow-up email.

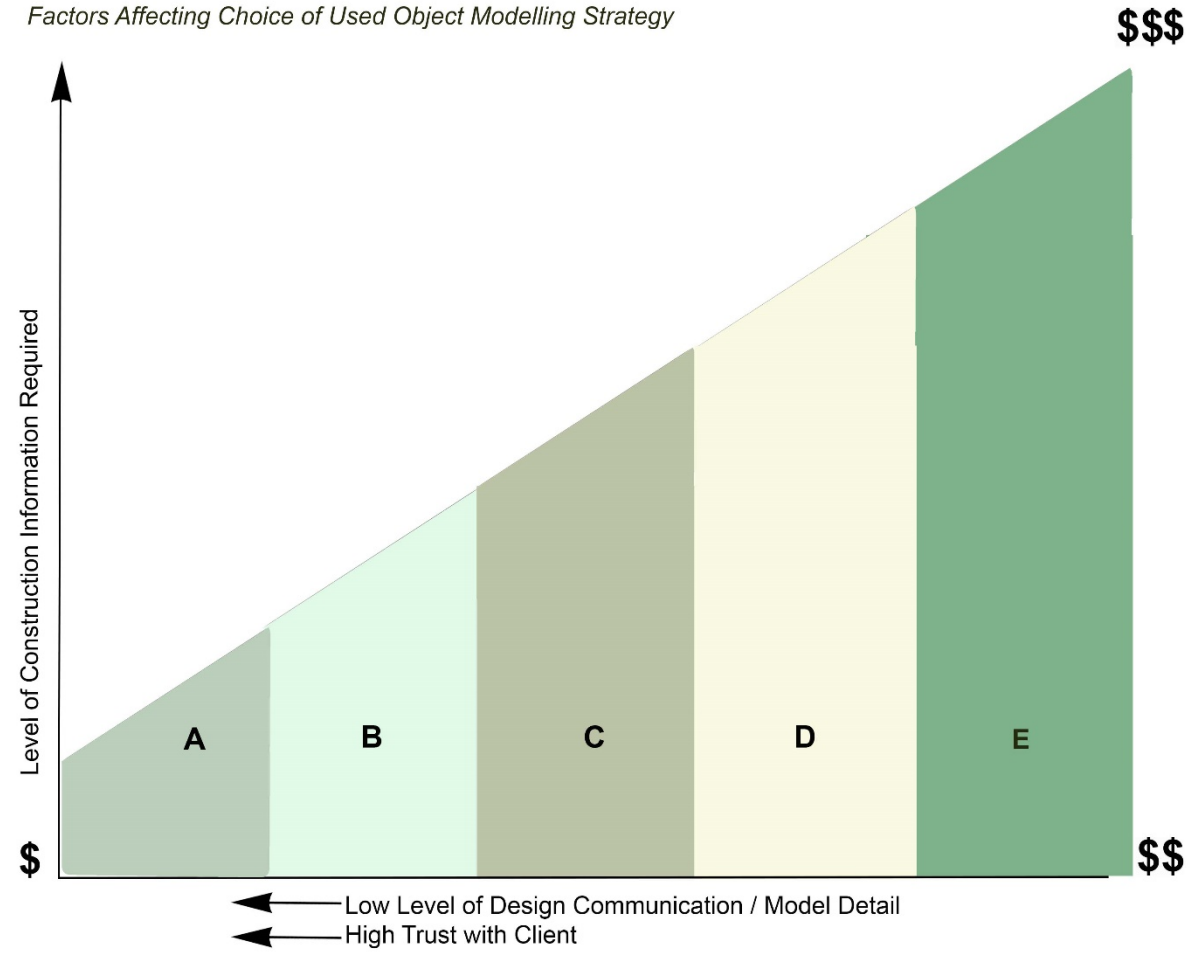
Community consensus was also measured by whether the projects had won industry awards. A Google search was undertaken to identify whether any case studies were award-winning. It is acknowledged that the researcher may not have located all awards.

Survey Content

Figure 11, presented to designers via the surveys, serves as the researchers' "abstraction… to connect the phenomenology of [the] experienced reality [of digitally modelling used components] into academic debate" (Pink 2015, p. 142). Survey One focused on interrogation of Figure 11. Survey Two asked about agreement or otherwise with Figure 11, but also asked about the respondents' experience with rematerial practice and digital modelling of used materials more generally.

Figure 11

Modelling Options for Used Components into Digital Designs



A - Use of an approximated stand-in digital twin adjusted to dimensions of actual item. Used with call-out of 2D image of actual item. 2D construction details.

B - Creation of a simple 3-dimensional shape (eg. rectangular prism for buffet) constructed to dimensions of actual item, with image of actual item mapped onto 3D object. 2D construction details.

C - Use a 3-D scanner to scan the item in-person and create a 3-D model of the item. 2D construction details.

D - Create detailed model of item using separate materials for all elements. Used with call-out of 2D image of actual item to show any blemishes. Construction details from 3D object.

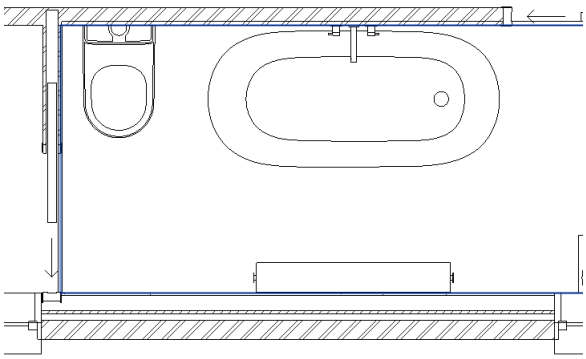
E - As per D, however with blemishes or faults modelled in.

NOTE: All methods can optionally include BIM data. Methods D & E however will have far richer BIM data as each component can have data entered, rather than only assigned to the digital model as a whole.

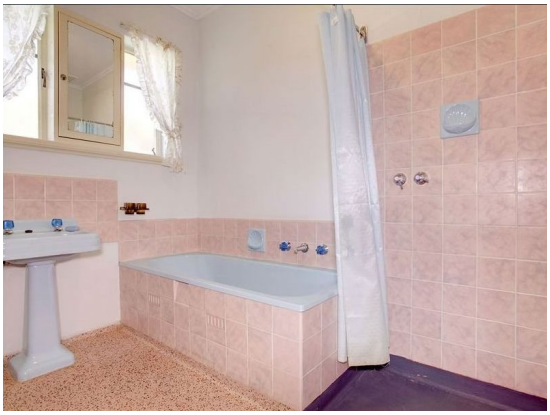
Figure 12 provides examples of Methods A and B in action, for example, where the author has found a used bathtub, but inserted an 'off-the-shelf' digital bath model and adjusted this model to the dimensions of the actual used bath. In this instance, this is sufficient to communicate the design when accompanied by the image of the specific used bath.

Figure 12

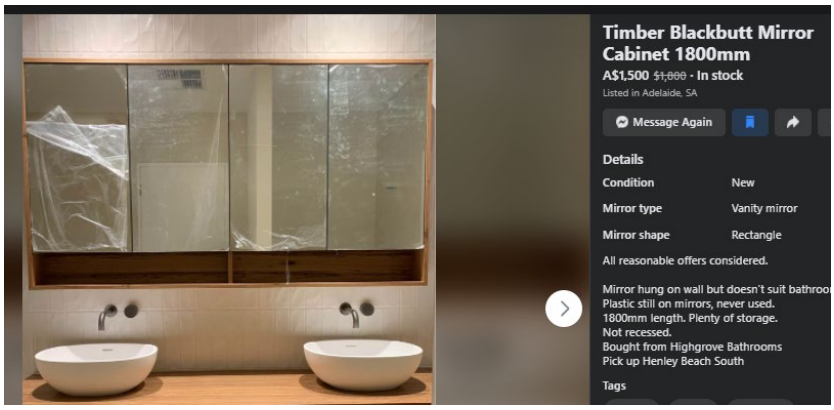
Example of Method A in Figure 11



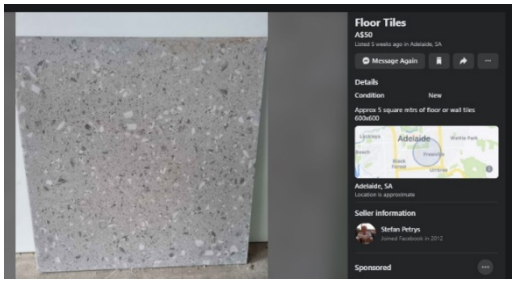
Example of Methods A and B in Figure 11



Original bathroom.



New ‘used’ wall cabinet purchased for project.



New ‘used’ tiles purchased for project. Small quantity.

Construction progress shot.

Digital image of new design using Method A for cabinet and slatted timber, Method B for the tiled walls. The sink is modelled even more simply, a cylinder with ceramic material – no detail.

The process model in Figure 11 is not intended to be deterministic (Hammersley, Foster & Gomm 2009, p. 4). Instead, it is representative of what the literature and practice experience indicate *has been done*, not necessarily what is to come. Being an emerging field, rematerial work has no established "norm" (Hammersley, Foster & Gomm 2009, p. 7), hence there are options and a spectrum quality to the model. The model does, however, act as a shared discursive tool.

As part of Survey Two, Figure 13 was provided to survey respondents to give their assessment as to how long it would take to digitally model this used item.

Figure 13

Image of door set provided in Survey Two.

Method 3: Reflective Practice

In the pursuit of triangulation of data, and overtly acknowledging that academic analysis is not "isolated… from the researchers' embodied knowing" (Pink 2015, p. 142), the researcher reproduced the "knowledge of a reality… in some substitute medium" (Groat & Wang 2013, p. 91) by undertaking her own rematerial projects during the course of the research. The researcher timed 11 rematerial modelling tasks that formed part of her design process. The online project management tool Clickup was used to record design processes. This time included finding publicly-available BIM objects where appropriate, adjusting photo

files, making errors, having difficulty finding files. The researcher began the construction phase of 2 of her 3 projects, hence was able to capture rematerial practices to this stage.

The researcher also undertook the modelling task asked of the survey recipients using modelling method B. This process was timed and screen recorded, including, again, the delays in the process such as not being able to connect to a server.

Scope and limitations

This thesis limits exploration of the feasibility of rematerial practice *within Australia*, and therefore the methods suggested (Figure 11) are designed for the current Australian context. However, as there are scant documented rematerial projects in Australia, the case studies used within this research are located across the world.

Respondents to Survey Two were not asked their age, gender or state/location, therefore the potential impact of these characteristics are not considered in this thesis.

Ethical considerations

The two anonymous online surveys were given ethics clearance by the University of South Australia's Human Research Ethics Committee (protocol number 204147).

Due to the dearth of available examples, and for use in triangulation, the researcher has included her own digitally-modelled rematerial projects as data. She has relied on her supervisor to check for sufficient critical reflexivity in assessing their contributions and limitations.

In representing case studies, the author acknowledges "representation itself as a tool of oppression" (Rendell 2012, p. 3), and that due to the criteria set by the researcher (in

particular not including projects using manual construction processes), the case studies in this research barely represent the design and construction sectors of developing countries. The problem with this, is the greater experience and knowledge of these countries in rematerial work is hidden, subtly suggesting the projects aren't worthy (which is not the case), and preventing inspiration to be drawn from their pioneering and extensive work.

This thesis was produced on unceded, illegally-colonised Kaurna country by a member of the colonising ancestry. Kaurna people were not expressly asked for their opinion about the matters in this thesis. This is an area of work that should be completed, and allowed to have influence, before any implementation.

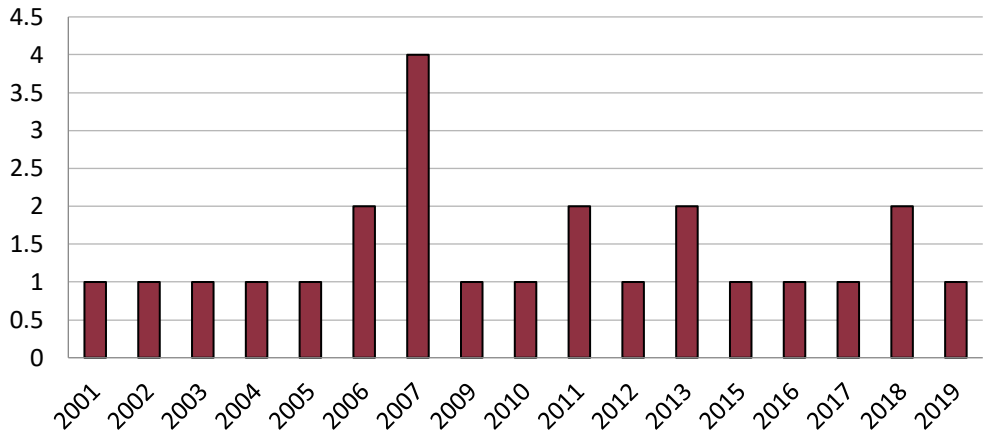
Results

Results of Method 1: Case Study Analysis

24 case studies were included for analysis, spanning almost two decades; 2001 to 2019. 10 countries were represented with the USA, Spain and the Netherlands accounting for over 50% of projects.

Figure 14

Year case study projects built



The projects spanned landscape, interior and structural architecture, with most (almost 90%) being a mix of structural and interior architecture projects. Most were new build projects (61%) with some being renovation (22%), extension (13%) or a mix of these (4%).

Only 25% of these projects were single-dwelling residential, the rest were public (33%), education (18%), commercial (21%) and medium density housing (4%).

Figure 15
Project Type

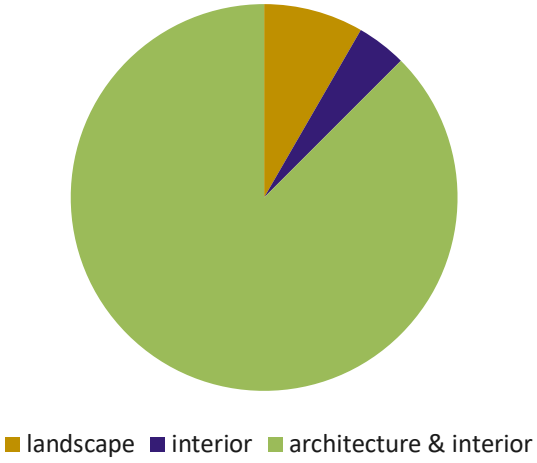


Figure 16
Project Locations

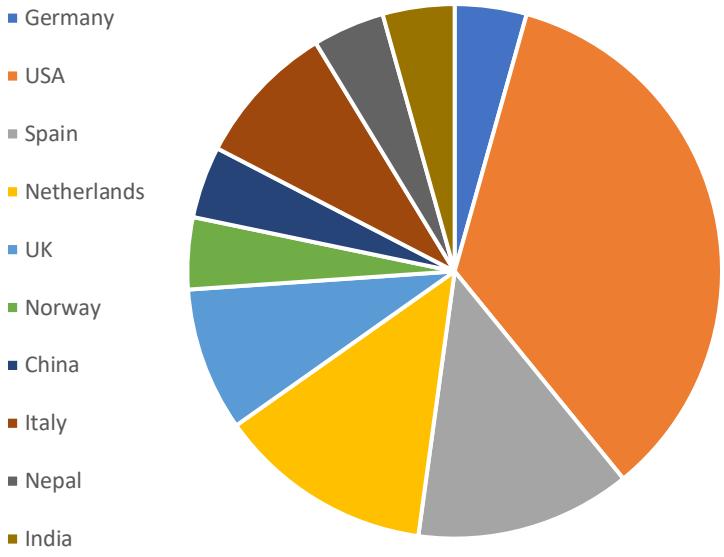


Figure 17
Build Types

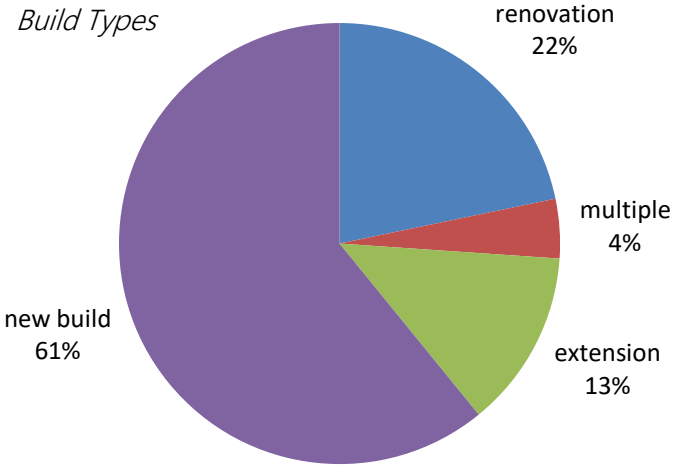
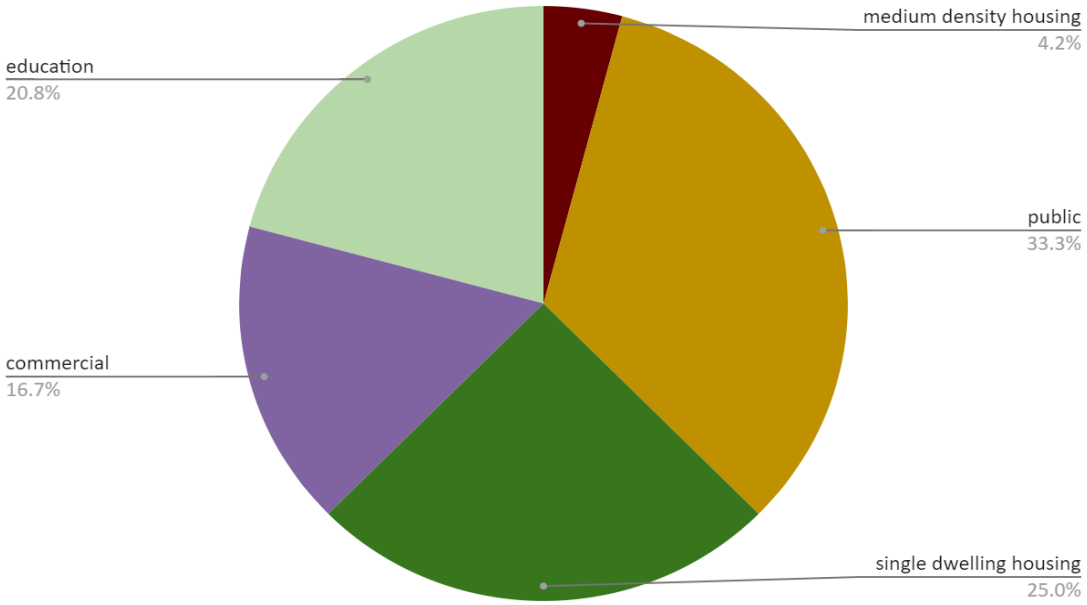


Figure 18

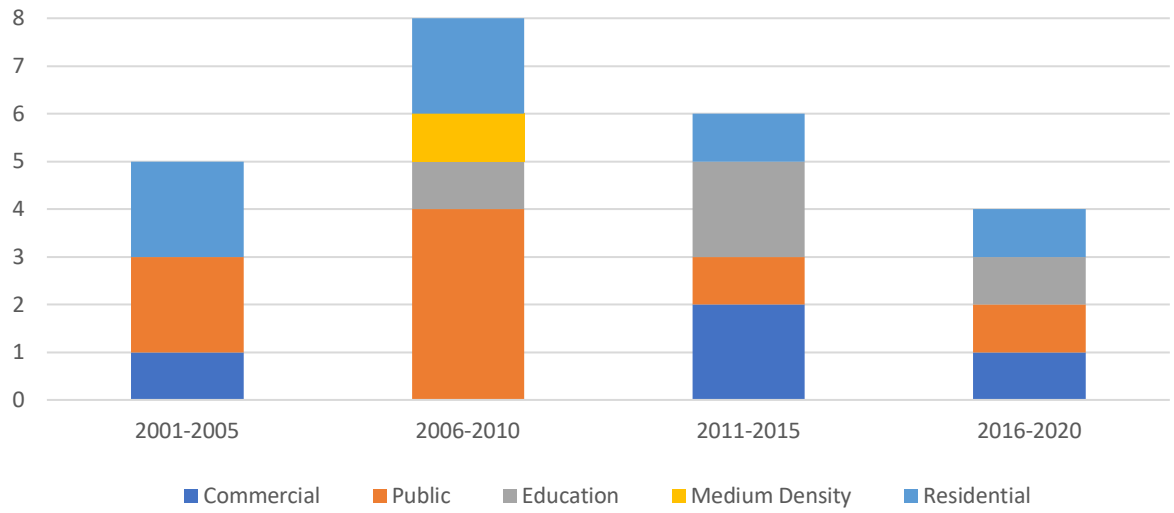
Project Contract Type



Residential projects were more likely to have been built in the first decade, with more commercial and education projects in the last decade (Figure 19).

Figure 19

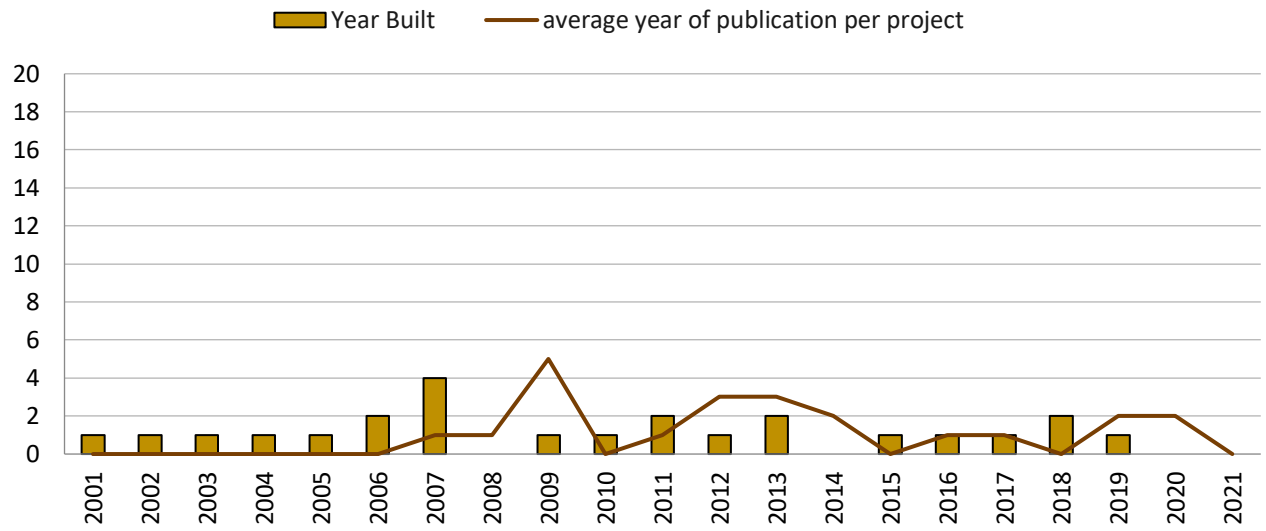
Number of case studies with each contract type collated into 5 year brackets.



Half the projects have won design awards, one third have won environmentally-focused awards (see Figure 49 and Table 4 in Appendix 5).

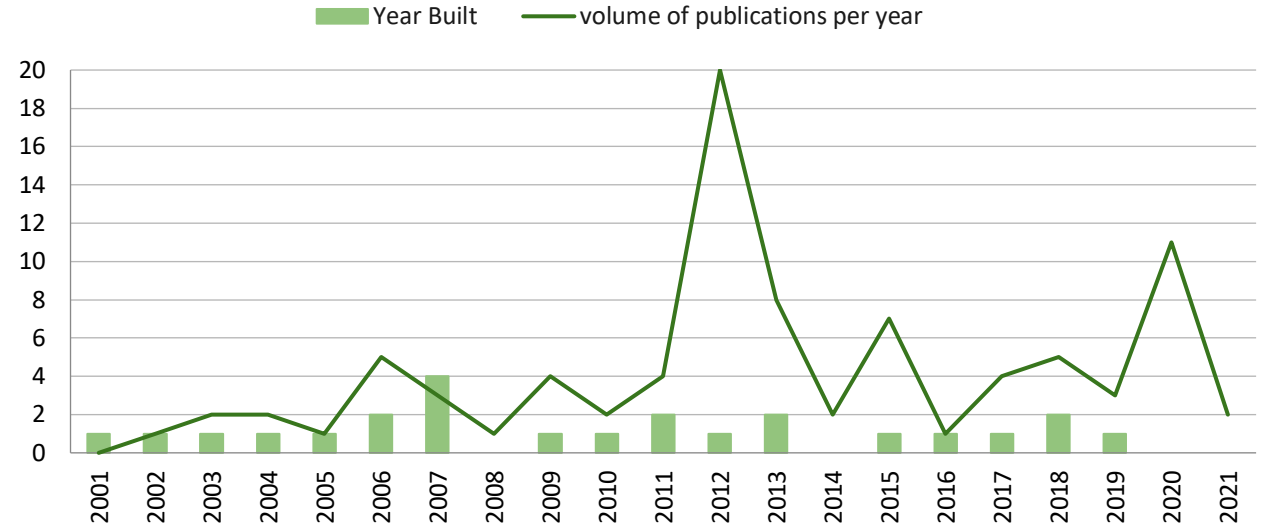
Interest in this practice (specifically these case studies) has grown in the last decade within architecture industry publications. This is visible by looking at the average publication year for each project, and mapping this against build completion year (Figure 20).

Figure 20
Year Built & average year of publication



When each publication is accounted for (Figure 21), this becomes further evident. A spike of interest in 2012 is now returning. Remembering the last case study project was built in 2019, yet in 2020 the case studies are generating the second-highest spike of interest in two decades.

Figure 21
Year Built & volume of publications per year

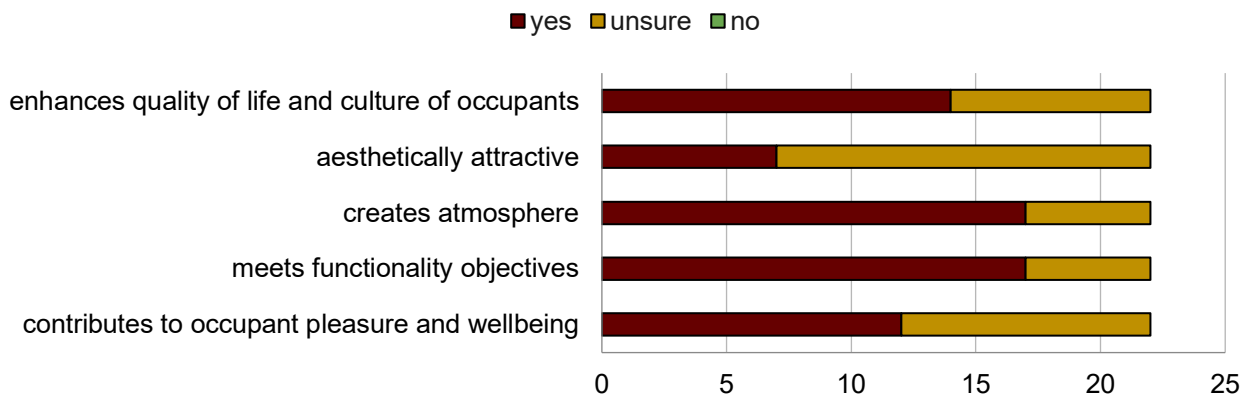


Semantic Case Study Analysis

Figure 22 below presents the researchers' manual analysis[18] of whether the corpora indicated the case studies had achieved literature-endorsed design goals. Figure 22 shows all case study projects met the design goals to some degree.

Figure 22

Researchers' manual findings regarding case study's achievement of design goals



The researcher identified over half the case study projects as having enhanced the quality of life and culture of occupants. Commentary on the projects from people other than the designers included that the architecture is "a vital force in the... cultural community" (Schroll Guz 2021), "conserving the rooted memory" (Kwok 2015) and "symbolising ... reconstruction" (Patrizia Foundation nd)[19].

1/3 of the projects were described in ways that signified aesthetic attractiveness: "sculptural" (Bahamon & Sanjines 2008, p. 46, Kwok 2015), "simple and striking" (Vernet & Wit 2007, p. 148), as being "elegant and modern" (Shea 2009), "beautiful" (Bahamon & Sanjines

[18] Data included as Appendix 3

2008, p. 168; Maynard 2006), "charming" (Divisare 2020), and "aesthetically pleasing" (Keegan 2011).

71% of the case studies were deemed to create atmosphere through non-designer authored text. Descriptions of "aura… alienation… confusing" (Petzet 2009), "draw[s] people in" (American Institute of Architects (AIA) nd.), "austere but welcoming" (Bahamon & Sanjines 2008, p.64), "exhilarating" (Goldberger 2007), "spaces that are hidden or revealed by light… luminous atmosphere" (Bahamon & Sanjines 2008, p. 136), "unexpected" (Migliore 2020) and "iconic" (Lawrence Business Magazine 2012) supported this finding.

71% of the case studies were deemed to meet functionality objectives. The list of amenities provided and enhanced are listed in Appendix 3.

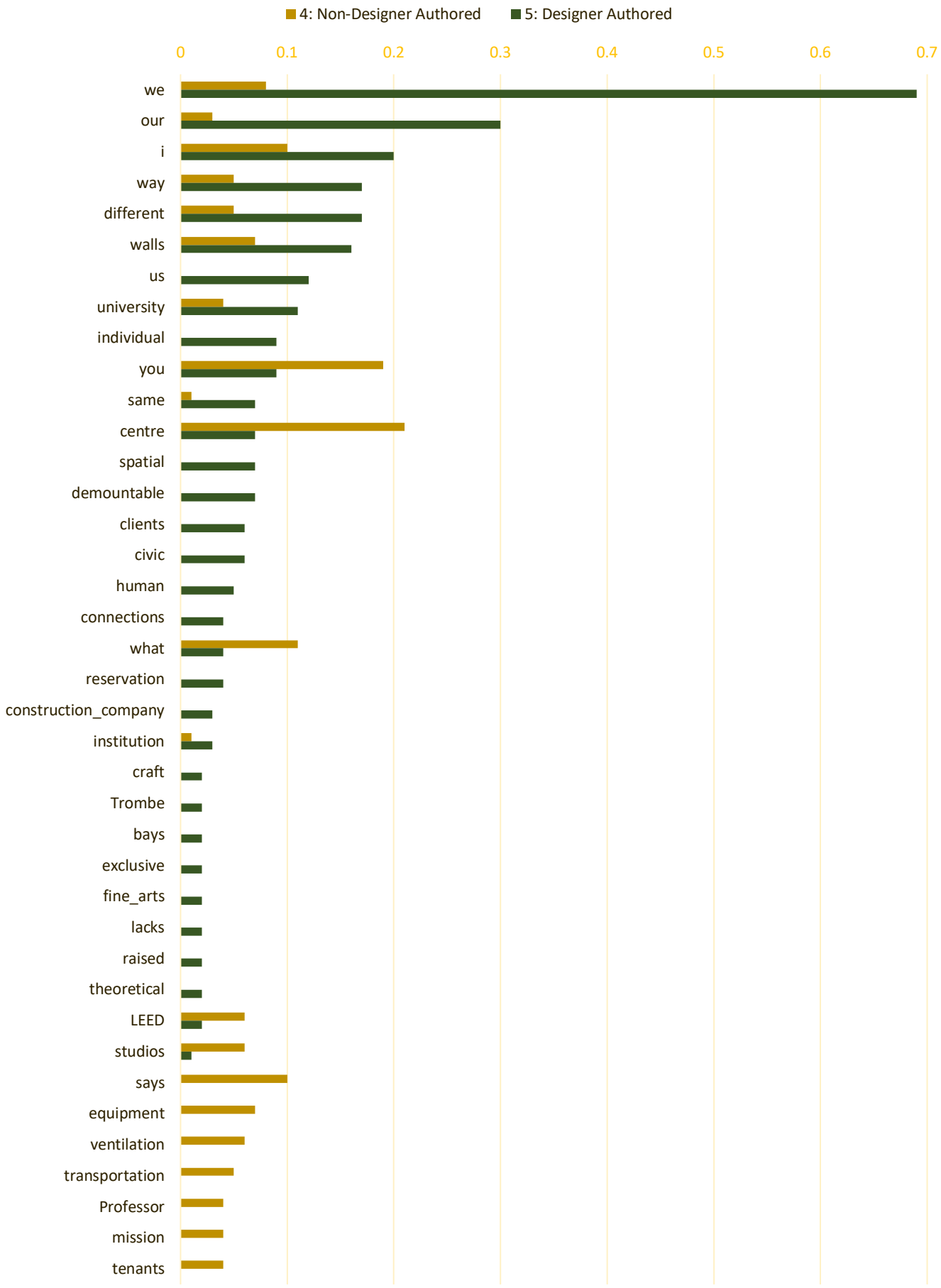
50% of case study projects were described by non-designers as contributing to wellbeing and pleasure; providing excellent access to sunlight/daylighting (AIA nd., raumlaborberlin nd.), maximised natural ventilation (Bahamon & Sanjines 2008, pp. 34 & 168), "landscaped to provide shade and habitat, attract birds and insects" (AIA nd.), and as having "multiple" and "breathtaking" views (Zukowsky et al. 2004, Patrizia Foundation nd.).

The remaining semantic analysis was achieved through the Wmatrix software. Unsurprisingly, apart from word particles, Table 1 and Figure 53 (Appendix 7) show the largest word usage in discussion on rematerial projects was 'design' and 'building'.

The semantic analysis found clear differences between what text the designers of rematerial work generated, and what text non-designer authors generated. Figure 23 shows the words in corpora 4 and 5 that have the greatest degrees of difference in use between the cohorts. Designers talked more about people (we, our, I, us, clients, human, civic) with the exception of the word 'you', which non-designers used more. This makes sense in terms of

Figure 23

Relative Frequency of words with a dispersion norm > 0.1, meaning the words with the greatest difference in use between designers and non-designers.



asking designers about their work (similarly for 'centre', 'studios' and 'Professor'). Designers more often used creative and qualitative terms such as 'craft', 'fine arts', 'individual' and 'exclusive'. Non-designers used more systemic and practical terms such as regarding environmental certification, 'transportation', 'ventilation' and 'equipment'.

In terms of the language of the environmental aspects of rematerial work, Table 1 (Appendix 7) shows clear differences in language use between designers and non-designers. Non-designers used the language 'recycled' and 'sustainable' (with Figure 23 showing a greater propensity to discuss 'LEED' accreditation). Designers used the terms 'waste' and 'circular'.

Figure 57 (Appendix 7) shows that with regard to arts and culture, the level of discussion regarding design was fairly similar between designers/non-designers, but non-designers exclusively used the terms 'artists' and 'arts', whereas designers exclusively used the terms 'craft', 'fine arts', 'sculptural', 'decoration' and 'ornamentation'. Both groups discussed 'cultural' matters, but designers used the verb form 'culture' more often.

Wmatrix provides data on semantic categories as well as single terms. Figures 57 to 66 in Appendix 7 detail the relative frequencies of the semantic categories, and detail some of the categories at the word use level. Figures 24 and 25, and Table 2 below add to these.

Through Figures 24 and 25, the semantic categories 'life and living things' and 'world and environment' demonstrate quite a divergence of interest between designers and non-designers. Of the most-used words in the first category, non-designers hadn't used 54% of them at all. 'Garden' and 'life' were the words most commonly used by designers in this category, and they used 'garden' three times, and 'life' twice as often as non-designers.

Figure 24
Life and Living Things Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

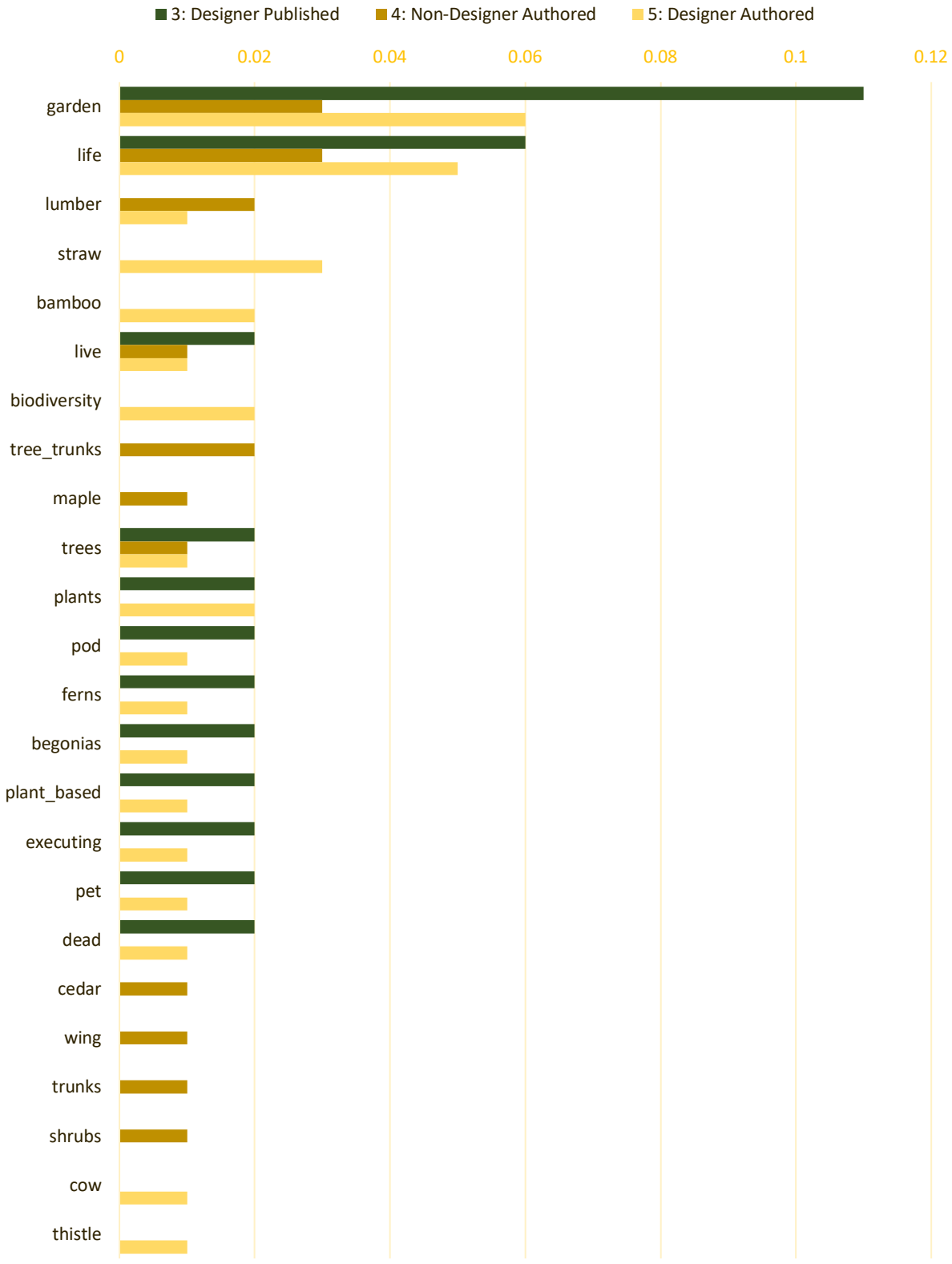
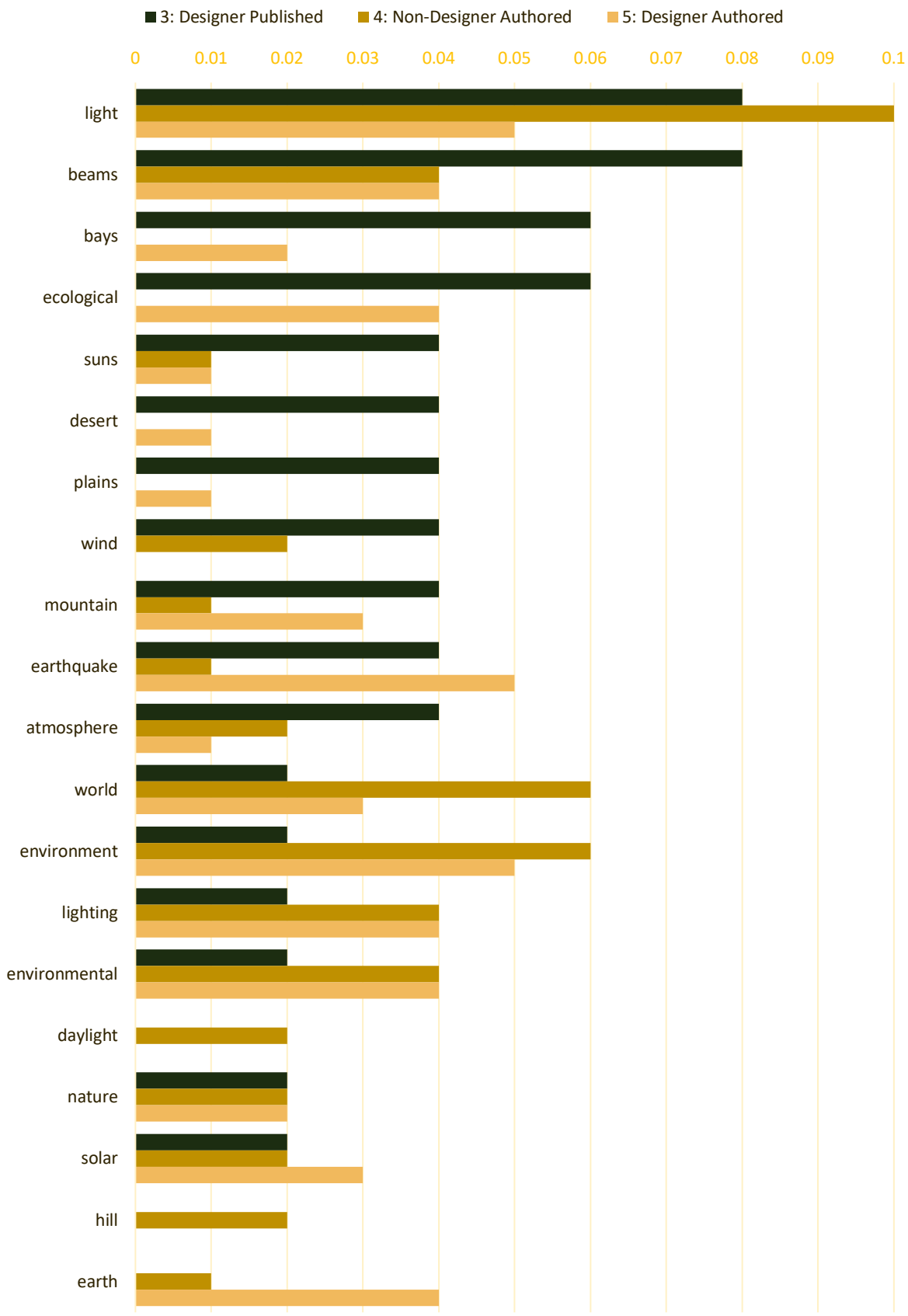


Figure 25
World and Environment Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency



In the semantic category world and environment' non-designers more-often discussed 'light', 'lighting', 'world', 'environment' and 'environmental' than did designers. Designers used the word 'ecological' where non-designers didn't and more often used landscape or atmospheric terms ('deserts', 'plains', 'wind', 'earthquake', 'atmosphere' and 'earth').

With regard to Figure 50 (Appendix 7) that presents text generation in Wmatrix's 'materials and objects' semantic category, both cohorts used all bar one ('equipment': non-designer only) of the most-used terms in this sematic category, indicating congruency of interest. Designers generated text about the 'circular' nature of materials and objects twice as often as non-designers, and discussed 'conditions' six times more often.

Within the 'architecture' semantic category, designers discussed 'construction', 'walls' and 'roof' more often than non-designers, but overall there was little difference between the cohorts on this topic (Figures 58 and 60, Appendix 7).

Wmatrix's 'language and communication' (Figure 64) and 'social processes' (Figure 65) semantic categories identified different foci between designers and non-designers in these areas (see Appendix 7). Designers used the terms 'people', 'public', 'association', 'assembly', 'together', 'collaboration', 'talks', 'discussions', 'negotiations', 'needs', 'question', 'debates', 'proposal' and 'engagement' at least twice as often as non-designers for all of these words.

The biggest differences in the psychological processes category, was non-designers more frequent use of the terms 'approach', 'mission', 'efficient', 'system' and 'systems', and designers' of 'idea', 'plan', 'planning' and 'decided'. The words 'experimental', 'techniques', 'experience' and 'dynamic' were used at least twice as often each by designers.

Table 2 presents the semantic word category summaries that Wmatrix produced.

Table 2

Wmatrix software-produced semantic word category summaries by Designer/Non-Designer-authored corpora.

word category:	negative		positive		ing		negative emotions		positive emotions		ed (verbs)		roles	
shared by designers & non-designers														
not shared, unique to each author category														
author:	designers	non-designers	designers	non-designers	designers	non-designers	designers	non-designers	designers	non-designers	designers	non-designers	designers	non-designers
most frequent	new	new	is	is	building	building	fear	harass	rest	rest	used	used	doors	homeowners
	different	part	can	can	housing	using	cross	frustration	joke	popular	recycled	recycled	others	designers
	part	other	also	also	working	existing	tension	tension	resting	taken to	need	designed	layers	visitors
least frequent	affordable	single	was	all	planning	housing	quake	cares	like	celebrating	designed	created	partners	doors
	individual	small	are	are	using	recycling	rammed	quakes	prefer	trust	reused	salvaged	suppliers	members

The clearest differences are in who the authors discuss (non-designers feature consumers of projects, whereas designers feature participants), the negative terms (non-designers use language of scale, designers use language of uniqueness) and the emotional tone.

Finally, in reviewing 24 rematerial projects, there was not a single mention of digital documentation by either the practitioners or by article authors, in spite of evidence that 75% (18) of these projects had been documented digitally (see Appendix 8). All this can tell us was that digital modelling was not part of the conversations or text-based information offered through these publications, but it contributes to evidence that information regarding digital modelling of used items is difficult to find for a professional seeking to understand the effort involved. This leads us to the semiotic analysis.

Semiotic Case Study Analysis

The analysis found that 75% of the case study projects had been digitally modelled to some degree. This may be more widespread within the case study projects, but this is the

evidence available within the corpus images. Figures 26 and 27 are examples of images that were considered to indicate a case study project had been digitally modelled:

Figure 26

Officina Roma. 2011. raumlabor.
Image credit: raumlabor.net

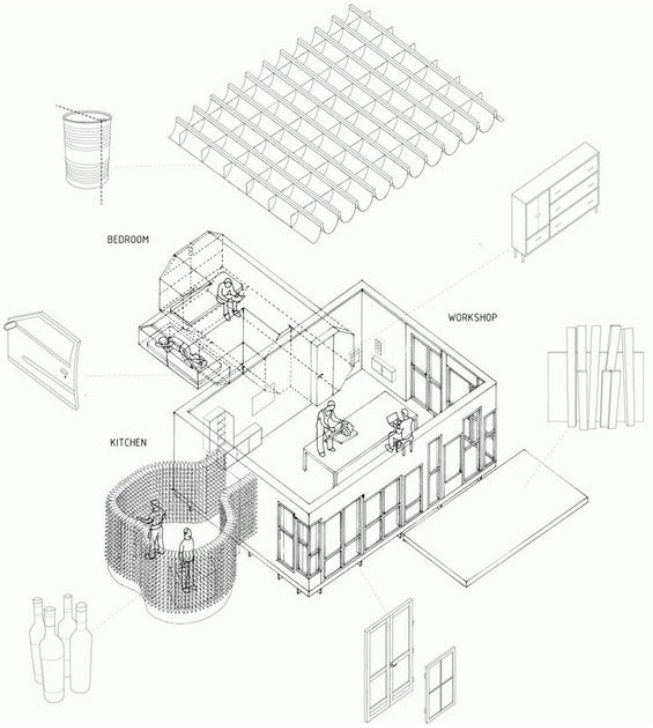
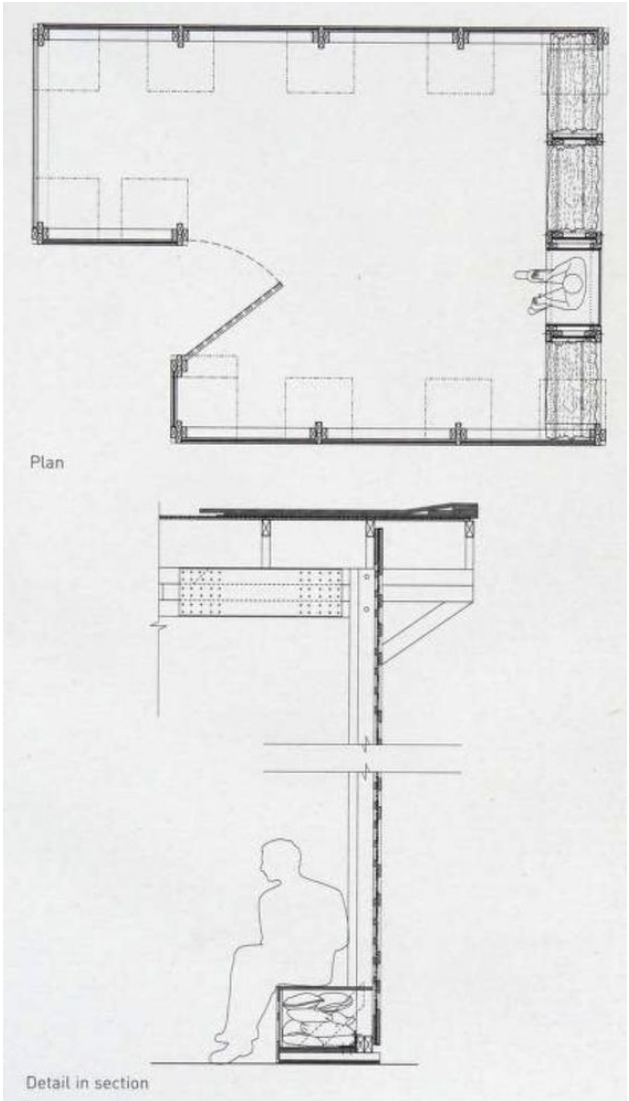


Figure 27

Space of Waste. 2007. *School of Architecture, University of Sheffield*
Image credit: Bahamon & Sanjines 2008, p286



Appendix 8 comprises the 99 images and their corresponding 'match' from the online architectural image zeitgeist (or blank white image to signify a match could not be found)[20]. 92% of the corpus was able to be matched to a similar image of an architectural project. Following are some examples of these matches:

Figure 28

Case study project: Ecohawks Research Facility. 2013. Studio 804, University of Kansas
Image credit: studio804.com

Figure 29

Wikov Locker Rooms. 2014.
Architect not known.
Image credit: Benedikt Markel, archinfo.sk

Figure 30

Case study project: Trailer Wrap. 2007. University of Colorado. Image credit: Bahamon & Sanjines 2008, p.173

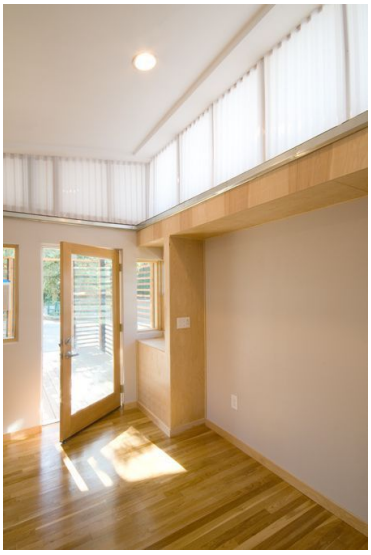


Figure 31

Floating Boat House. Yasuhiro Matsumoto Architectural Workshop. Image credit: raumlabor.net

[20] For sources see the Pinterest site www.pinterest.com.au/rock3867/rematerial-projects-v-architectural-zeitgeist/

Figure 32

Case study project: Centre for Research Design. 2011. Studio 804 University of Kansas School Studio 804. Image credit: architectmagazine.com

Figure 33

Ipekyol Textile Factory. Emre Arolat Architects. Image credit: europaconcorsi.com

Figure 34

Case study project: St Anna Monastery Residential Complex. 2009. Hild und K Architekten Image credit: hildundk.de

Figure 35

Herrenkamp. Wannenmacher-Möller Architekten GmbH. Image credit: archinect.com

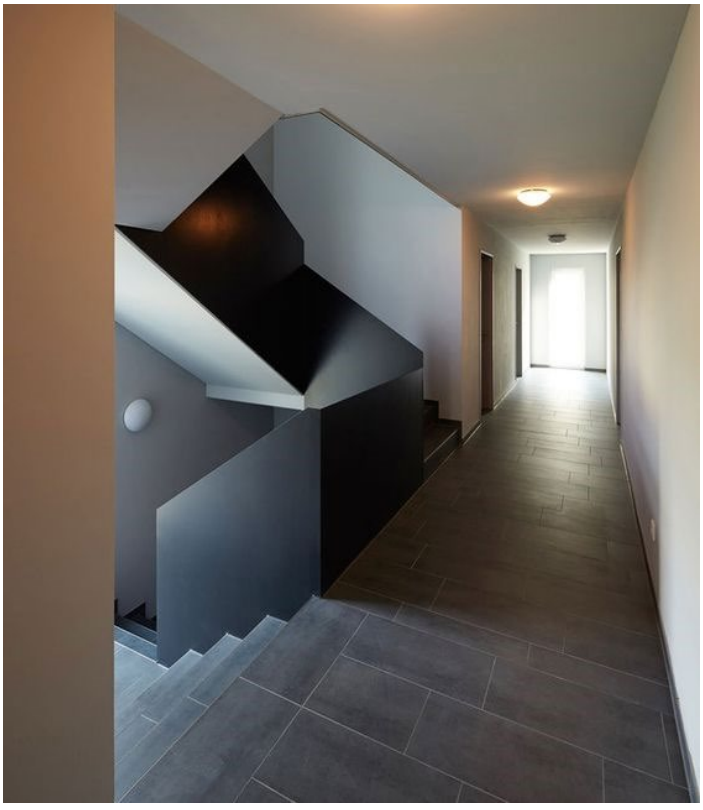


Figure 36

Case study project: Studio MOA. 2015. Atelier GOM. Image credit: archello.com

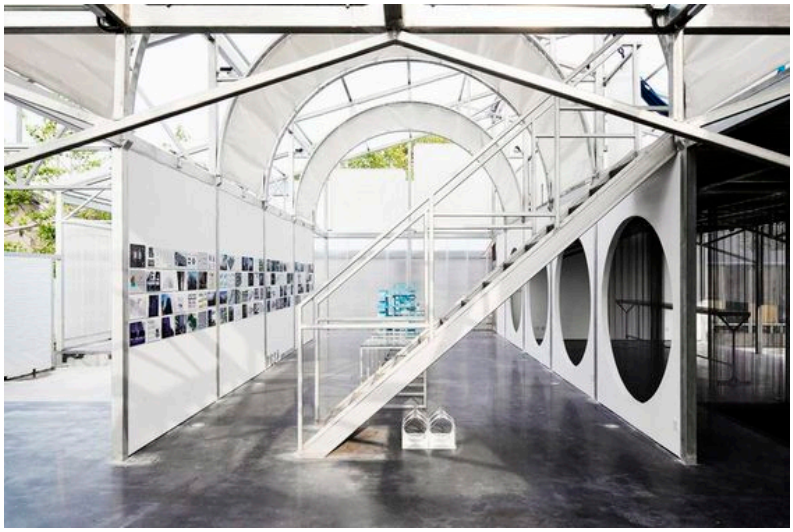


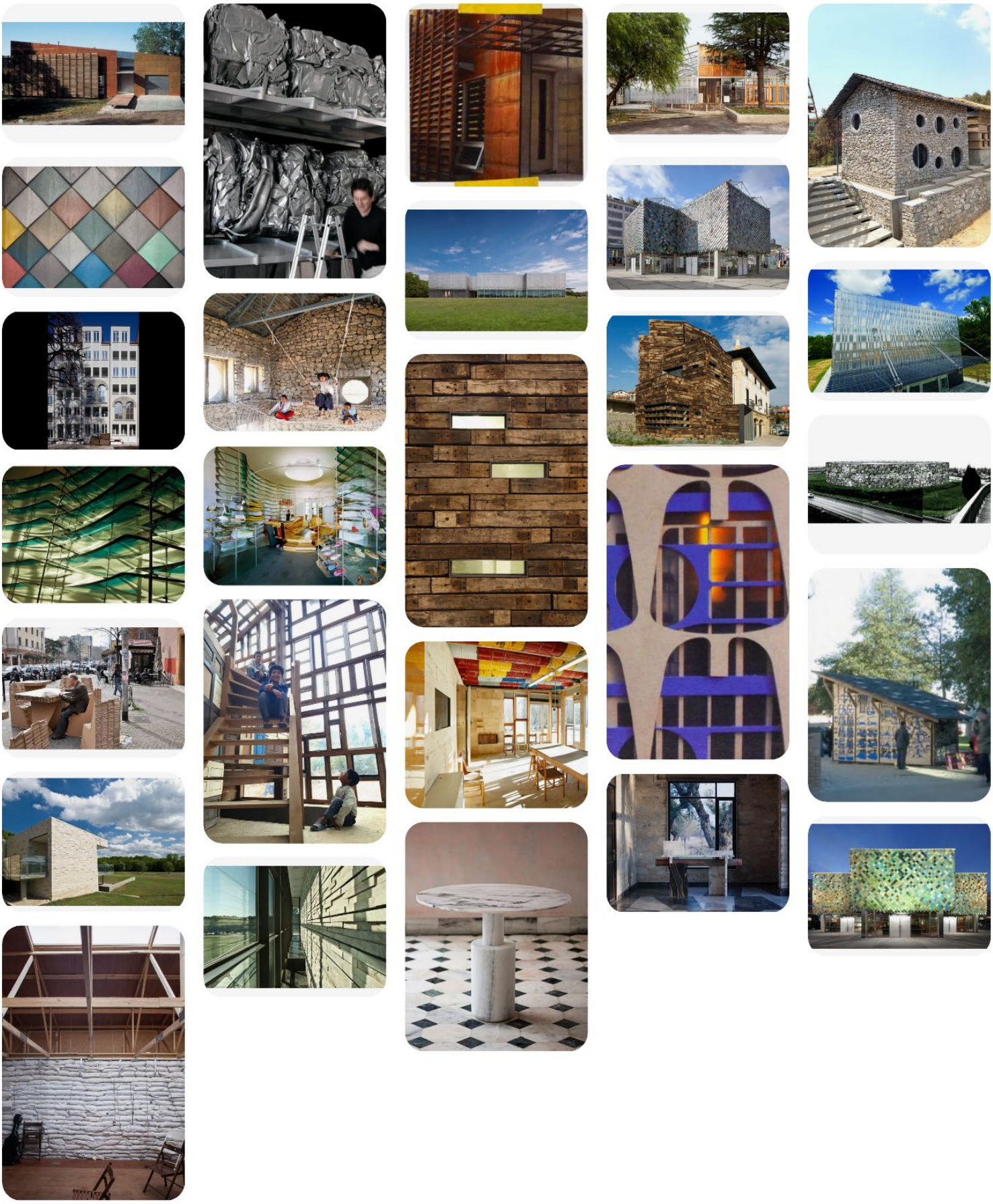
Figure 37

Starbucks Coffee Journey. Image credit: Pei Yu Cai

2/3 of the case study projects expressed a vernacular of layering and stacking in their design. This can perhaps be understood as a result of the sometimes-fragmented nature of recovered components, and hence a design strategy of necessity. Images in Figure 38 represent this.

Figure 38

The vernacular of layered construction within the case studies (images taken from sources listed in Appendix 1)



The following eight images (8% of corpus) from eight of the projects (33%) were sufficiently unique that the researcher was unable to find corresponding aesthetics in a non-case study project/image[21]. Unique architectural projects are not unusual outside of rematerial projects also.

Figure 39

Images of case study projects that have a unique aesthetic

[21] Sources listed in Appendix 1. For specific images see www.pinterest.com.au/rock3867/image-set-3/

Results of Method 2: Industry Surveys

There were two respondents to Survey One (8% return rate), with one respondent based in the Netherlands, the other in United Arab Emirates. Both are architects who have been in their current role for over 10 years; one in a professional association, the other in education. Both felt Figure 11 reflected their rematerial practice.

The low response rate requires this data to be used speculatively.

There were 16 responses from Australian-based designers to Survey Two.[22]

Rematerial work, as with architectural practice generally, is produced in concert with many different professional roles (Figure 40). Survey respondents came from the following: architect, interior designer, building designer, set designer, exhibition designer, visual artist and builder, representing a broad context that this work can occur in and relate to[23]. Most respondents were experienced in their design role, having occupied the role for over 10 years, with only one having been in the role for 5-10 years, and one for less than 5 years (Figure 41). Noting this trend one week into receiving responses, purposive sampling was conducted by sending targeted email invitations to 'young firms'. This made no difference to the high percentage of experienced practitioners who responded.

[22] Any respondent who answered "no" to the question of whether they primarily worked in Australia would have been excluded from the data, however all responded "yes" they primarily work in Australia.
[23] Note: one respondent identified as both interior designer and architect, therefore the total roles allocated are 17, for 16 respondents.

Figure 40

Australian Respondents' Professional Roles

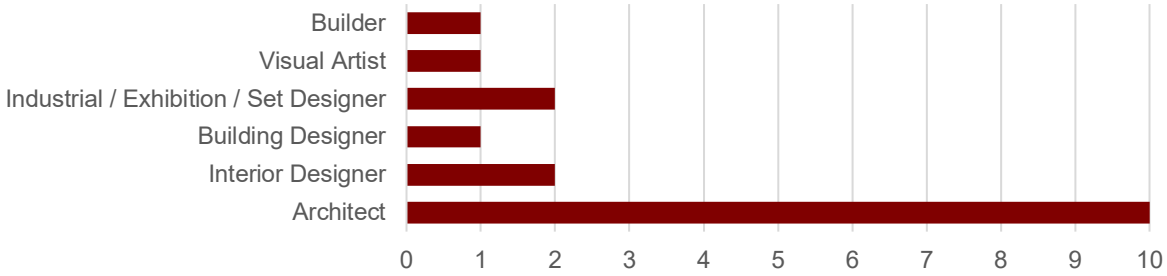
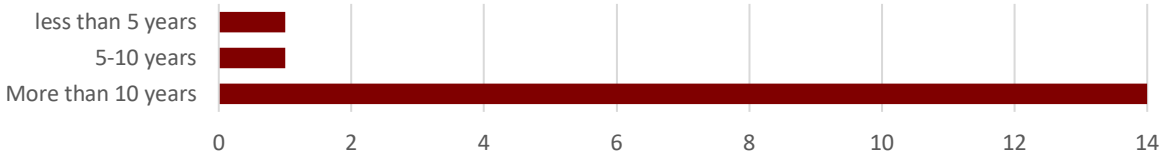


Figure 41

How long have you been working in this role?

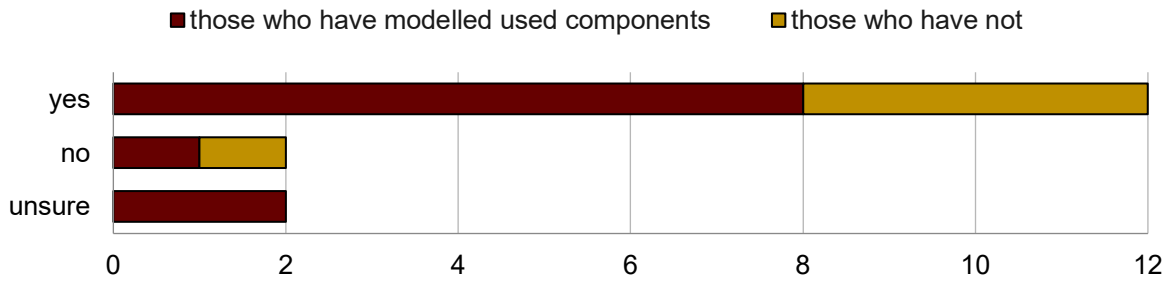


15 of the 16 Australian respondents advised they had physically incorporated used items into their projects. Of these, 73% (11) had also digitally modelled used items.

There was strong 'community agreement' (Groat and Wang 2013, p. 84) amongst the respondents that the methods proposed by the researcher presented a useful starting point; both case study respondents felt the model reflected their own practice, and 73% (11) of the Australian respondents described the model as a feasible practical approach (Figure 42). 13% (2) of Australian respondents were unsure and 13% (2) did not agree it was a feasible model.

Figure 42

Do you see the model proposed as a feasible practical approach to digitally modelling used items?



The respondents were evenly split on whether they felt the practices in Figure 11 represented economically feasible processes (between yes/no/unsure, Figure 43), however there was strong desire (14 of 16 respondents) to use digital models of used components *if they were provided* (Figure 44).

Figure 43

Do respondents believe digital modelling of used items is prohibitively expensive?

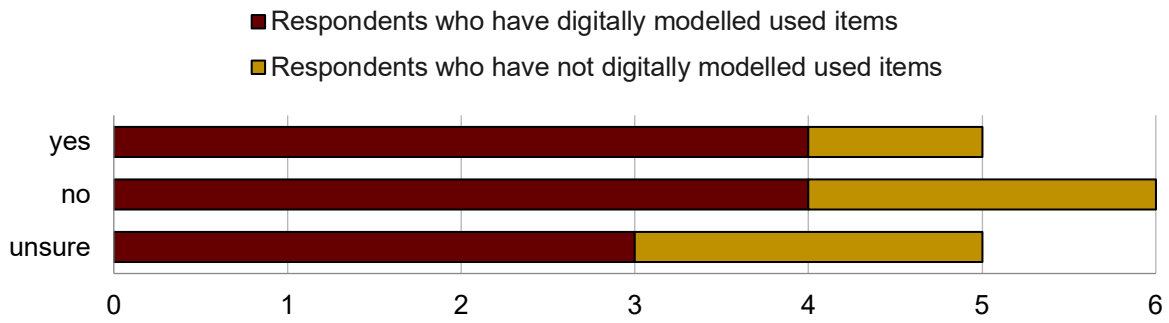
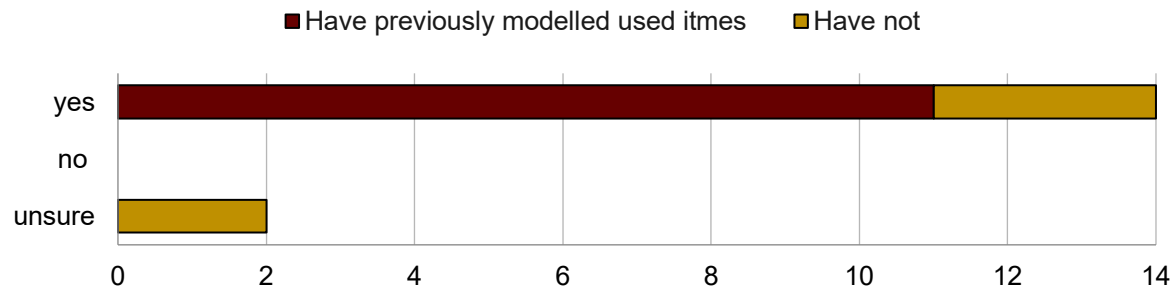


Figure 44

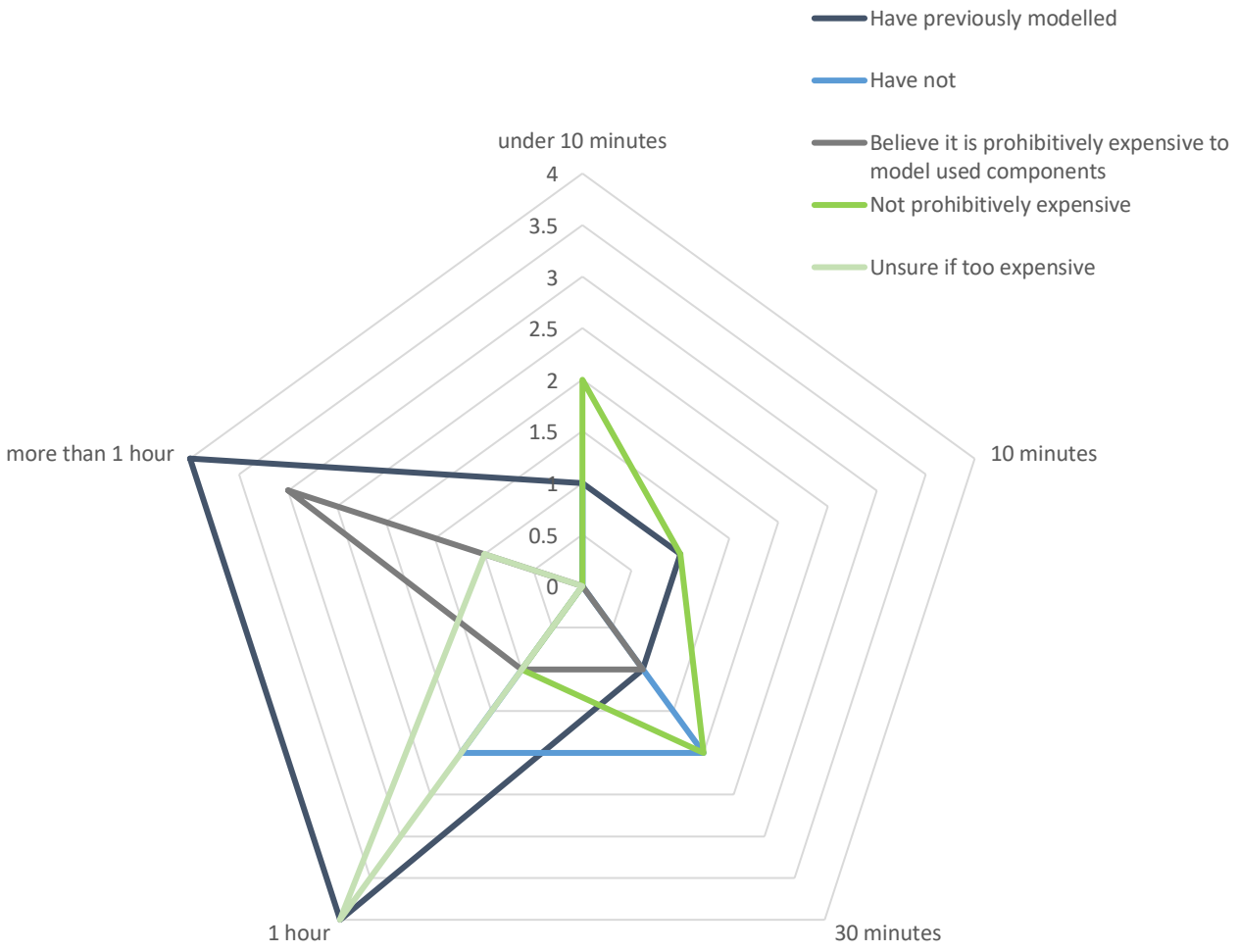
Would you incorporate used materials or objects into your digital designs if they were already digitally modelled for you?



Whilst respondents were evenly split on the perceived cost of digital modelling, when faced with a specific modelling scenario – modelling a specific door set (Figure 13) – some (conflicting) patterns emerged. There was a clear relationship between whether or not a respondent believed digital modelling of used items was economically feasible, and how long they imagined the specific task to take. 90% of respondents who were unsure or believed digitally modelling used items was financially unfeasible, believed it would take one hour *or more* to model the door set, whereas 83% of respondents who believe it is financially feasible, assessed it would take 30 minutes *or less* to model the door set (Figures 32-34, Appendix 7).

Figure 45

Relationship between expense beliefs, modelling experience and time assessed to complete modelling task



Respondents who had prior experience modelling used components, were also most likely to estimate the modelling task to take over an hour (Figure 45).

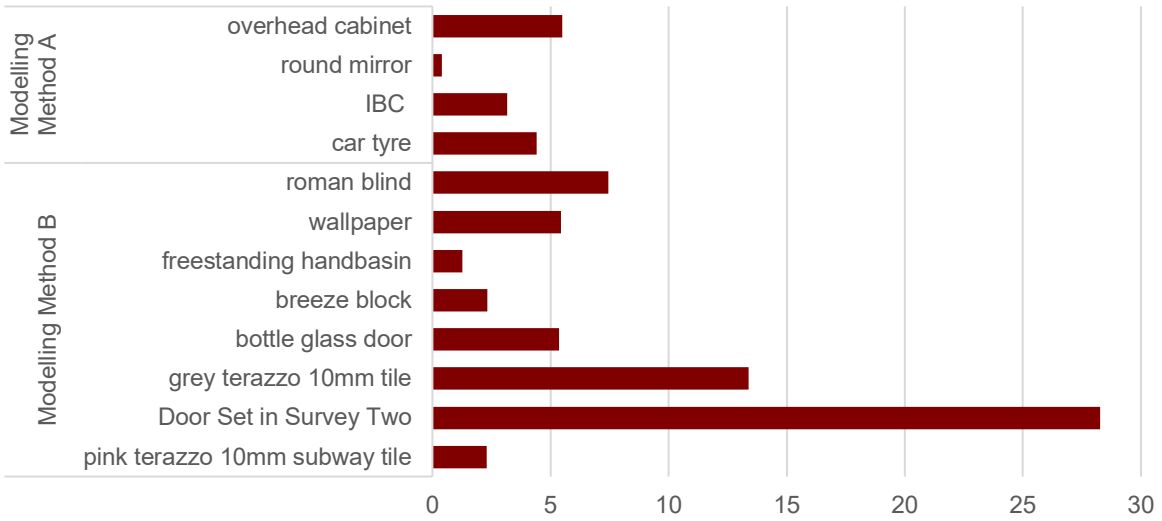
Results of Method 3: Self-Reflective Practice Analysis

Including time spent attending to non-modelling issues that arise during the usual course of practice such as being unable to locate a file or the computer freezing, the researcher took on average 4.6 minutes to produce the simple models required for her rematerial projects.

For the door set modelling task that Survey Two participants estimated, the researcher took 28.27 minutes to complete. Unlike all other models in Figure 46, the researcher didn't have dimensions for this item, hence extra time was spent estimating and adjusting for this[24]. When this model is included, the researcher's average production time was 6.6 minutes.

Figure 46

Time researcher took to digitally model components into rematerial projects.
In minutes



[24] The researcher took a screen capture of this process. It shows the amount of time spent with file issues (my computer wasn't talking to my offsite file storage for a while) and estimating sizing. The full process including adjusting the original image in Adobe Photoshop is included in this video and time. See the recording at thisisradas.com/rematerial

Discussion

Nilsson Björkenstam (2013, p. 4) argues that a "corpus can rarely provide explanations", while Kretzschmar et al state that the "analyst is always responsible for explanations", where they are put forward (cited in Rayson 2008, p. 17). The researcher will not provide explanations as such, but discussion of the results and their relationship with existing research and literature.

In terms of the questions addressed by this thesis – is rematerial work good design? is it practically and economically feasible? – when taken together, the semantic and semiotic analyses, the survey responses and reflective practice data, viewed through a feminist lens, indicate that yes, rematerial practice is all of these.

Sub-question One: Is it worth doing; is it good design?

Environmentally, there is strong agreement that reuse is 'worth it', however for the design sector, the first question of worth is: is it good design?

In relation to quality of life and culture, Chau attests to Shu's celebrated reuse practices as preserving the "vernacular fabric and its deep connection to local history and culture" (2018, p. 111), and as generating, along with Chipperfield's reuse practice, "reflective nostalgia" that strengthens connection to place (pp. 116, 118). Over half the case study projects were similarly described by authors other than the designers. Rematerial designers' attention to this arena is also supported by their linguistic focus on/concern for people (Figure 23 and Table 3), their commitment to engagement and discussion (Figures 64 and 65 in Appendix 7) and their willingness to discuss 'culture' (Figure 57 in Appendix 7).

The semiotic analysis shows that for the overwhelming majority of rematerial project images, there are projects offering images with a very similar aesthetic (Figures 28 to 37 and Appendix 8). At least in terms of what projects are of interest/published, *the rematerial case studies hold par aesthetically*.

1/3 of the projects were described in strongly positive aesthetic terms, and, where rich layering is a desired aesthetic - what Hewitt (cited in Chiveralls 2018, p. 217) and Telfer (in Gorgolewski 2017, p. 42) refer to as beautiful and inspiring "interplay of shape and color" *sic*. - the semiotic analysis showed rematerial processes are an avenue to achieving this (Figure 38).

The case study projects won more design awards than environmental awards, attesting to their achievement of environmental responsibility not coming at the expense of 'good design'.

These rematerial designers' linguistic focus on creative and qualitative terms such as 'craft', 'fine arts', 'individual' 'sculptural', 'decoration', 'ornamentation' and 'exclusive' attest to their concern for aesthetics.

71% of the case studies were deemed to create atmosphere through non-designer authored text. Designers' linguistic direction toward uniqueness (Table 3) and dynamism (Figure 66 in Appendix 7) is likely to have propelled this outcome. 1/3 of the projects were either unique, or had unique elements (Figure 38), which in exposing people to an embodied experience of newness could be said to create atmosphere, and excite the senses to the possibilities of rematerial work, through the experience of natality (Arendt & Canovan 2013).

The achievement of functionality objectives (Gorgolewski 2017) could be implied in the awarding of public, commercial and educational contracts to projects with rematerial processes (Figures 18 & 19). This aside, 71% of the case studies were deemed to meet functionality objectives due to the quality of provision of amenities (Table 3 in Appendix 3).

There was no discussion of failed functionality within the corpora, but there was media coverage of one community's fight to keep one of the case study projects that was meeting their needs, but became earmarked for council demolition (Coultate 2017).

Over half the projects were identified from the corpora text as having contributed to occupant pleasure and wellbeing (Table 3 in Appendix 3). Achievement in this area is no doubt supported by rematerial designers' interest in the natural environment (Figures 14 & 21). Brand also suggests that "age" is the "single most loved characteristic of buildings" (cited in Gorgolewski 2017, p. 265). Rematerial projects have a head-start in generating this loving connection as increased age is intrinsic to the materials. In this way also, rematerial projects could be said to contribute to occupant pleasure.

Rematerial work encourages austerity, but not as a lack, or 'bare life' (Agamben cited in Zaera-Polo 2011, 112). Austerity in a rematerial context invites intensification of experiencing what one *has*. Where mass production sought to "rid ourselves of the romantic" (Le Corbusier 1987, p. 151), rematerial practice seeks to re-instill this. There is therefore a joyful, sensual intention to the design process in "contemplat[ing] more deeply the multitude of values and roles we ascribe to matter" (Solanki & Corbin 2018, p.7). Rich engagement with materials has led to successful design outcomes with, as stated earlier, half the case studies winning design awards, some several (Appendix 3). Recalling that discussion of the design credentials of rematerial projects is absent from the majority of journal papers published on the practice, it is clear that is not because the projects lack these credentials.

Sub-question Two: Is it practical?

This question asks if it is practically achievable to undertake digitally-modelled rematerial projects. The results indicate that from single-dwelling houses to larger

commercial projects, rematerial projects *are* being undertaken, and *have* been digitally modelled.

Whilst the surveys did not specifically ask about accuracy and rigour, some respondents offered data in relation to this. One survey respondent reported tradesperson "reluctance" to work with used materials:

> *"the reluctance of builders to work with… re-used materials is the largest factor in its lack of uptake, many designers would love to re-use materials if their builder would let them… many [tradespeople] do not have the knowledge or inclination to work with these… materials" (A<5A).*

The author has experienced this reluctance (/resistance) repeatedly in practice.

So the concern arises to address builders' and trade staff barriers, in order to address designers' barriers. Respondent A>10D offers the opinion that

> *Modelling isn't the issue. It's all the new regulatory NCC/BCA compliance issues that stop me mostly… compliance with 'only new materials' specified in government and institutional contracts. Often also many residential projects. Difficult to manage unless top down the initiative is understood. Doors and Windows etc don't typically… meet… the new NCCBCA requirements.*

Recent literature reports industry agreement that "the lack of standards/certificates that assure the quality of secondary materials to fulfil the technical specifications and building codes… are the major barriers that hinder [reuse]" (Ratnasabapathy, Alashwal & Perera 2021).

Whilst the absence of technical support is a concern that needs a response, "mass production… [as] an illusion of precision" (Le Corbusier, 1987) is a perception/cultural issue that also builds barriers to use (and therefore modelling) of used items. With not too much scratching of the surface however, the perceived uniformity of new products can be easily called into question. Tradespeople grapple with 'standardised' products not actually being manufactured to their standard specification. For example, 300x300mm is considered a standard tile size in Australia, whereas it is mainstream practice to produce and sell tiles that are 297x297mm or 295x295mm. When a 295x295 feature tile is placed next to a 600x600 tile (that is *actually* made to that measurement), a 10mm difference is a large accommodation to manage. This accommodation is treated as a known pain point when the item is new, but prejudicially experienced as an avoidable obstruction and delay if the item is used.

Another concern about used materials is that "if [bespoke components] are damaged or found to be un-fit, a replacement may not be readily available" (A<5A). Whilst this is true, the author argues this risk is equal for new bespoke items, and at times there can be external factors that impede access to even new *standard* items (Doran 2021).

Differences or delays encountered with used materials seem to be received with prejudice; if 'the window doesn't fit', this is about poor documentation, not about the used item. This happens with new windows also. This is a cultural issue requiring dialogue and knowledge development.

The low numbers of case studies examined do not support a trend analysis but does suggest that rematerial practice has increased in the commercial and education sectors in the last decade (Figure 38). This is noted here as these are fields with high due diligence. These projects have met the rigorous requirements of the tendering process; evidence that it is not

used materials that are the issue, it is the lack of systemic support and education in how to utilise them, including digitally.

Rematerial practice is a call to "imagine, empathise with and experience matter in new ways"; "to embrace a new, materialist mode of practice" (Goodbun & Jaschke 2012, pp. 31-32) that takes materials as they are. Manzini calls to complement this respect for materials by developing 'error-friendly design/systems' (2011, p. 58) that can respond to the variances that exist within *both* new and used materials, as do faults exist within both.

An experienced rematerial practitioner, Andrea Zittel has made up her own word to represent the value return of some rematerial work; "sfnwvlei" (something for nothing with very little effort involved) (cited in Smith 2011, p. 177). In rematerial projects, that something for nothing can look like swapping out new standard materials for the same standard item, but used, provided at no to low cost (being somebody else's waste). This can often be delivered free to site, avoiding dumping fees for the giver. In this way, for some rematerial projects there is no difference to the digital modelling task required; the product looks the same digitally (eg. a steel beam).

Another approach is to source the component prior to modelling. This still equates to modelling Method A (Figures 11-13), but will directly influence the design process and outcome, as the design is being created with the dimensions of what is available, rather than materials sourced to fit the design.

The next type of digital modelling is that of highly variable off-the-shelf items such as fittings (tapware) and loose furnishings (couch), or other artefacts/objects. Previously all of these items had to be custom modelled or a stand-in provided, with detail clarified in Schedules. The provision of BIM objects by sellers allows designers to side-step this particular modelling task, however as mentioned earlier, sellers of used items are not currently

providing these[25], and are therefore are at a competitive disadvantage of being selected by designers.

Finally, there are custom-created elements to designs that regardless of whether these are made from new or used materials, will need to be uniquely modelled. "Often we model artifacts as part of our design process, this is time consuming but integral in our work". (Respondent A<5A). There is no difference in effort or cost for this type of modelling between rematerial and other projects. Survey respondent A10+A summarises this: "There's no difference between modelling used elements than there is custom new elements: they're either in the… [digital modelling] system, or they're not (in which case you have to create them from scratch)."

The question in Survey Two estimating time required to model the door set in Figure 13, was never intended as a trick question, but has served to illuminate that rematerial work is steeped in perception, rather than shared practice knowledge and data. The data from the researchers' practice[26] shows it is possible to model this door set in 28.27 minutes, and it is possible to produce simple digital models in an average of 6.6 minutes (Figure 35) – nowhere near the hour or more many respondents estimated the task would take (with the caveat that simple modelling methods A and B were used). Those who believed digital modelling of used components to be prohibitively expensive, and those who had previously modelled used items, were most likely to estimate the task at over an hour duration (cost). It could be said however, that all respondents 'should' have replied as being *unsure* how long the door-

[25] Unless they are newer used items and therefore part of a recently-developed digital catalogue, but mostly not. PatinaBIM.com are working on a digital model market for used items, but are yet to launch.
[26] I would consider my modelling skills to be average in terms of process (time) and output. I have not achieved this time because I am 'good at' modelling.

modelling task would take, because the method of modelling was not specified, and makes a big difference to time required. Respondent A>10C offered

> *This is about how much complexity is required to be shown. If these doors were a known object [to the client and builder], then a simplified representation of them could be shown in the architectural documents for construction. If the doors were required for visualisation, such as rendered images, then either a complete digital model needs to be created [Method D], or a photograph could be mapped onto a plain surface [Method B] during the rendering process to reduce modelling time.*

A shared understanding of indicative time investment required for each of the modelling methods is not available, so one's *perception* of cost or what modelling method is available, influences (/distorts) the estimation.

This is true also for BIM, however many design projects do not require the level of detail BIM provides[27]. The decision to operate with BIM would not be made with regard to used/new material type, but regarding broader project management needs (for example, deciding to incorporate a used beam would not necessitate BIM, but the project being specified from within the modelling software would).

Where BIM is used, it is not a given that BIM processes will be more time-consuming with rematerial work. Respondent A5-10A signposts this in offering that "many commercial

[27]"3D scanning of set dressing items is already used when difficult to document but putting this process under a BIM system would be pointless." (Respondent SD>10A), "The application may need to be identified first before dedicating time to modeling." (Respondent IED>10A) and "I have not used BIM to that level… for any kind of materials as I have not needed to" (Respondent BD10+A)

fitout providers will recycle raised floor tiles; the same could apply to all sorts of other common items, interior or otherwise. Consequently many [existing] BIM elements could be… [identified] as recycled simply by an additional… info tag" (eg. modelling method A with a note provided in the BIM). It is acknowledged however, that some "re-used material requires unique… data… [that] management of the supply chain for reused material does not easily support the acquisition of" (Ali 2016, p. 3).

This is particularly true for those who are working with minimal tolerances, or considering long material lifespans, "The wide range of potential variables, specifically related to material/component degradation and deformation" need to be understood to enable BIM to reflect the materials' "actual conditions" (Respondent IntAE>10B). An industry-shared understanding of what to record, and how to record it within BIM in terms of the used nature of items, needs to be settled on. Countries such as the UK now mandate BIM use for all public projects. The heavily researched and industry-tested BIM standards and Level of Detail requirements used in these countries could be referred to for insights into systemic approaches to BIM for used objects. This work has begun by authors including Cheng at al. and Rose and Stegemann (cited in Faisal & Mihály 2021, p.10), and thanks to initiatives such as the European Union having policy targets supporting materials reuse and complementing this with a BIM-based Buildings as Material Banks project (Faisal & Mihály, 2021). Self's work (Architectural Association School of Architecture 2021) to provide practice wisdom on "how idiosyncratic material, precision 3D scanning and digital modeling can be coordinated" (Respondent IntAE>10B) will also progress the efficient incorporation of BIM into rematerial projects.

Lastly, all 5 respondents who indicated that they had not digitally modelled used items, had been in their role for over 10 years, and all bar 1 of these 5 *had* physically

incorporated used items into their projects. For this quarter of the respondents, incorporating used items was not dependent on digitally modelling them into the project. An opportunity for further study is to analyse what types of components are incorporated by this group, and what their documentation practices are in relation to the used items. It may be that these respondents are doing what respondent A10+D does: "I often reuse smaller elements - bricks, timber, so not necessary to model really". It is not possible to know if this was offered in the context of not digitally modelling *any* of their project, or whether they were in fact referring to modelling Method A, where standard-issue digital bricks and timbers can be used to represent the used items.

To progress these matters, development of shared language about methods would be useful (eg. Method A is 'model hacking', Method B 'prism mapping' or some such), and information about the different modelling processes and their usual time investment required, needs to be available to support decision-making to take up this work.

In 1969 Charles Eames succinctly captured the sentiment that effort in design work is considered essential to a quality outcome, and that design is replete with constraints to be danced with: "I have never been forced to accept compromises but I have willingly accepted constraints" (cited in Smith 2011, p.176). Another concept of effort, the "gesamtkunstwerk, the total work of art, with no detail left undesigned" pervades design history (Weinthal 2011, p. 144). Yet when it comes to rematerial work, constraints and efforts appear to be prejudicially considered a layer over-and-above usual design practice, when in fact there are always constraints of one kind or another, and details requiring focus. It is a myth to think that modelling used materials is an insurmountable burden compared to new materials.

If there is any hope of rematerial practices gaining wider adoption, the policy context will need to move forward to support and enable the enormous circular economy potential

that exists. The policy environment "exposes the cultural and political forces that keep ecological thought marginalized" (Boehneret 2011, p. 35). The semantic analysis mirrored the divide between policy (with non-designers focused on 'recycled' and 'sustainable') and the *statistics* on the priority issues (with rematerial designers focused on 'waste' and 'circular').

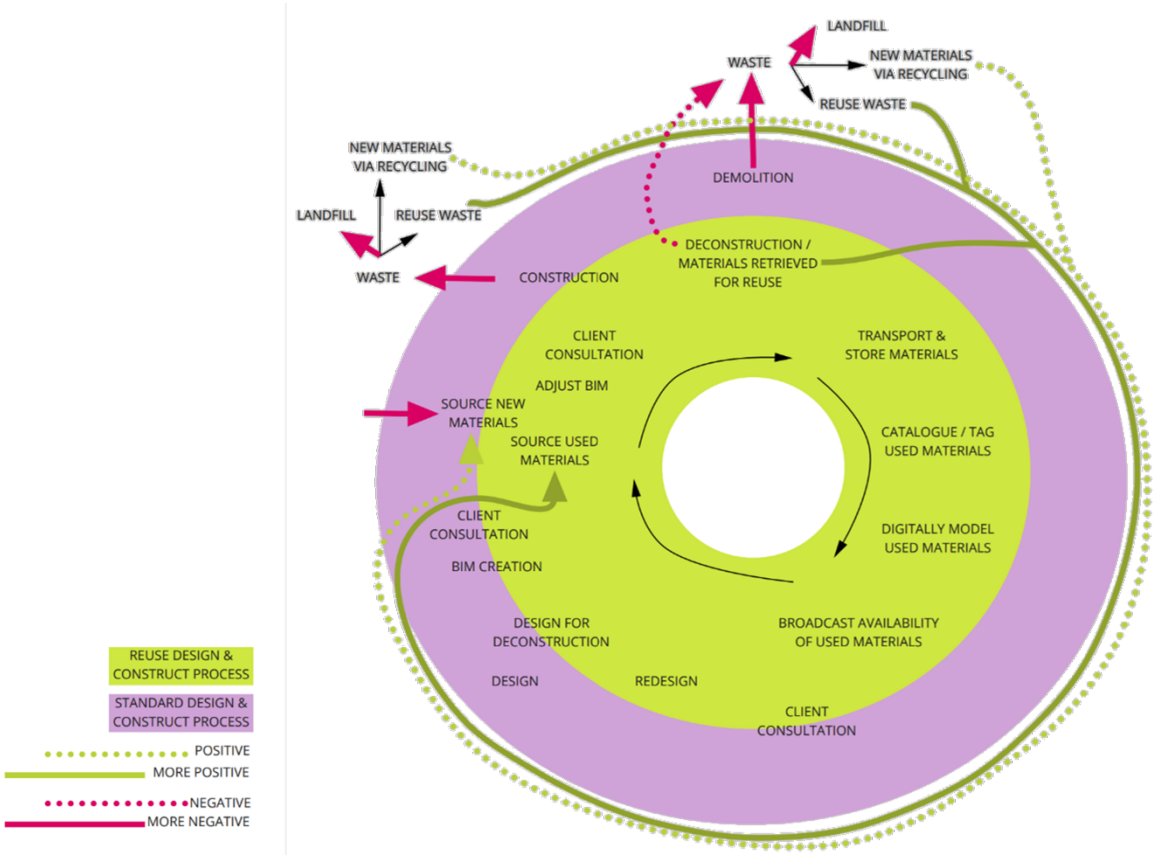
The literature on reverse logistics and design for deconstruction operates as if every project is the *start* of a closed loop, never the end/continuation of a prior-existing one (McGinley 2015, p. 3). That is, policy and practical direction is starting to be given for how to remove and catalogue items for reuse, but currently absent on how to bring these removed items *into* a project (Aguiar Costa & Grilo 2015, p. 109; Chong, Lee & Wang 2017, p.4116). The Australian Governments' circular economy representation (Figure 47) used in its latest Waste Policy Action Plan omits entry points other than raw or recycled materials, or mention of reuse (2019, p.2). This may be done for graphic simplicity, but given this is a time of education with regard to these practices, and reuse is more effective than recycling, these elements are perhaps worth including, as demonstrated in Figure 48.

Figure 47

National Waste Policy Action Plan 2019 Circular Economy Image

Figure 48

CD waste in a circular economy environment



Rematerial practitioners are revising the policy "stories we tell ourselves through the environments we create" (Schambelan 2008) by showing policy-makers the benefits and capacities of this practice by simply doing it, sometimes necessarily against policy regulations, sometimes within a void of them, and often, through deft negotiation of the prevailing policy context (raumlaborberlin nd.).

This is not an acceptable state of affairs given the magnitude of environmental problem this represents and the urgency with which responses are required. Rematerial work *is* practically feasible, but would be far more so were there structural supports for it.

Sub-question Three: Is it economically feasible?

Figure 31 shows there cannot be said to be Australian industry concurrence regarding this question however, the analysis above of effort required to produce digital models for used versus new components demonstrates that in general, the effort, and therefore the cost, will be the same. There is one significant modelling option where this differs; manufacturer-created digital models provided to designers on websites where physical models are sold. In this (becoming substantial) instance, designers incur no modelling cost. In this scenario, because used component trading sites (where the physical used items are sold) don't currently offer digital models, rematerial practice becomes economically less attractive at the design stage than new goods.

US materials trading platforms are primarily funded by advertising, memberships, and public and private funding (Pickin 2021, p. 222). Australia could invest in reuse systems with equal, if not more, enthusiasm as recycling systems. 132 key Australian C&D waste stakeholders concurred that "investment in technology" is one of the main drivers to stimulate markets for recycled materials (Shooshtarian et al. 2020, p. 229), such as support for digital modelling to be included in materials trading platforms as proposed in this thesis.

Much like keeping materials valuable/valued within a loop of use, rematerial projects offer "business opportunities" and "ensure that money cycles as many times as possible before it leaves" a community (Hopkins 2011, p. 75). Investment could be given to analysing what these business opportunities are, and their economic value.

Multiple waste trading schemes have had a short life span however (Shooshtarian et al. 2020, pp. 223-25). Insufficient market demand is central to this (Shooshtarian et al. 2020), and where the author returns to urging recognition of the digital design process as a key

moment in market engagement (and therefore development), and therefore financial viability of waste trading and reduction of waste.

Emerging Western rematerial practitioners have explicitly recognised the expertise of poorer communities who have far greater experience sourcing, reusing and building with used materials (Gorgolewski 2017). These practitioners urge rematerial work to evolve in ways that enable innovative 'shared economic and societal value creation' (Porter & Kramer 2011); that is, do not leave 'the Other' out of economic equations. Where we reduce waste picking opportunities for example, we could increase digital modelling work.

It is not that the practice of "urban mining" in developing countries should be stopped. Conversely, the practice should be increased in developed countries to "replace and complement the extraction of unrenewable resources" (Faisal & Mihály 2021, p. 2). A "magnitude of environmental harm can be averted [by urban mining], especially in the context of renovation activities and retrofits" (Faisal & Mihály 2021, pp. 4-5). Research has not been invested into the economic prospects of this work in Australia like it has for recycling. In its latest National Waste Policy Action Plan, the Australian Government plans to increase waste resource recovery out of concern for "losing the value of those resources", yet fails to factor in reuse (value upcycling) above recycling (value downcycling) for the trajectory of these resources. The Action Plan identifies that "for every 10,000 tonnes of waste that is recycled, 9.2 jobs are created, compared with only 2.8 jobs if the same amount goes to landfill" (2019, p. 10). Investment is needed in understanding how many jobs could be created from reuse-related work. But the unfair, unsafe, deathly and deprived manner in which this practice is devalued globally, needs reshaping to respect human and environmental life (University of Washington 2021, p. 59).

The environmental and economic costs of materials travel is not yet factored into the economic equations of "developed world" projects, "even those that are very 'green'" (Hopkins 2011, p. 75). Materials travel is usually included as freight, but the costs don't stop at freight; global warming causes economic loss. Yet we know conceptually, without any calculation, that due to the weight of construction materials, environment and economic costs are high for materials transport (McLennan cited in Hopkins 2011, p. 77). Policy and education on 'material miles' could drive reduction of the embodied energy in construction materials as it has with the concept of 'food miles' (Hopkins 2011, p. 75). Recovered materials are most often local. Here are those potential business opportunities in materials sourcing, preparation, modification and sales.

There is recognition that an "expendable aesthetic" (Parnell 2011, p. 132); planned obsolescence; "throwaway culture" (Weinthal 2011, p. 145), has no place in future design and consumption (Hartman 2011, p. 140, Crocker 2017, p. 5). Policy is yet to catch up with this notion, hence the deceitful "all-powerful gods of price and performance" (Le Corbusier 1987, p. 152), who promote the illusion of new product precision discussed earlier, get to dictate what is produced, and what materials it is produced from[28]. Consumers are given the opportunity to explain away (relieve the guilt of) their consumption practices as but a "social condition of… [policy's non-] emergence" (Butler 2001, p. 7); of there being no other purchasing choice on the market. Quality of production and materials choices are within the realm of legislation and policy, and the literature is clear the industry would like direction.

[28] Remembering the survey respondents' comment that some contracts require only new materials to be used in projects.

Through survey responses, we empirically know that rematerial projects have been built in Australia. A question then is, was anyone financially crippled or at a loss from them? There was no commentary in the literature, surveys or corpora to this effect.

The Australian C&D sector is supportive of increased waste disposal levies, but this disposed-of waste has nowhere to go. Investing in circular strategies such as waste trading markets that include BIM objects, urban mining and incentives (no fee) rather than penalties (increased levies) could produce a win-win.

The last word in this area of course, is that taking the planet itself as a key stakeholder, there is no economic equation that could be calculated to argue that the increased reuse of materials is not viable economically, because as Boenhert states, "without [a] functioning ecosystem… there will be no financial system to create this human construct we call money" (2011, p. 37).

Conclusion

This thesis set out to examine whether rematerial processes were practical and cost-effective processes that would produce 'good design' whilst at the same time reducing construction waste. Through a feminist-ANT methodology, this study shows that rematerial work is neither 'fringe', unattractive or sub-standard and the digital modelling of which can be implemented with acceptable levels of cost. As with any design practice, it can be exercised with skill and grace, or not. And as with any design practice executed by a professional, it is mostly exercised with skill and grace.

In 2013, Ali wrote "architects and building owners have the most influence on initiating [materials reuse]… The lack of helping tools, lack of "a system" and the lack of knowledge and

information available… are the biggest constraints for the design team in order to consider reuse." (p. 15) In Australia this is still true today. The digital modelling of used items is one small but powerful cog in this system. The survey responses in this research indicate that demystification and quantification – practice wisdom – needs to be developed and shared.

This thesis has sought to begin dialogue on the absence of "clear instructions" (Akinade et al. 2018, p. 376) on an aesthetic and technical "tacit skills"/design process (Flyvbjerg 2006, p. 222) required to reuse elements within a digital/BIM rematerial process. Process information is needed to *enable* the design community to *implement* their "high impact" position in waste reduction through design and specification (Aguiar Costa & Grilo 2015, p. 108; Akanbi et al. 2018, p. 177; Akinade et al. 2018, p. 383; Hayles 2015, p. 102). The community consensus regarding Figure 11 points to this as a shared discursive resource for the design sector to develop the practices/model further[29] (Groat & Wang 2013, p. 84).

Given the environmental waste crisis is already upon the anthropocene globally, action cannot wait for the design of a perfected policy and practice infrastructure within which to grow a rematerial industry. There is a sense of urgency attached to the development of new relating to existing matter, as councils, policy-makers, engineers, etc have demonstrated very slow innovation in this area (compared to recycling for example). We need to look at what action can be taken now, do so, and improve upon it.

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[29] Suggestions for development already made by both respondent cohorts include "It would be great if the BIM is something that can be added to other software types like Vectorworks too" (Respondent BD>10A) and "[The] Gap between B and C is too big, to jump to 3D scanning from basic geometry." (Respondent A5-10A). The latter is of particular interest as the availability of 3D scanning is growing significantly, but not necessarily training and knowledge on the practice. It is already possible to 3D scan using a smartphone for example.

A materials trading system with BIM objects is required as part of the (lacking) circular building system; to join "trading platforms" with the "end market" (designers and by extension clients and builders) as easily as these designers are connected to BIM objects of new items (Shooshtarian et al. 2020, p. 220; Crocker 2017, p. 11; Ratnasabapathy, Alashwal & Perera 2021). The Circularity Gap report concurs with the need to "strengthen connections between supply-chain actors through digital, online platforms and technologies" (2021, p.50). If used components are not in the digital design, there is unlikely to be a used component purchase/market, and this is a goal of Australia's National Waste Policy Strategy 14; to increase used market development. ALL survey respondents who had previously modelled used items reported they would use such models, and 88% overall said they would (Figure 30). Until such time as this market exists, designers can execute any of the methods described in Figure 11 to model such items.

The feminist-ANT perspective values the "exploration of new forms of architectural practice and production situated within the actor networks of modern material economies and ecologies" (Goodbun & Jaschke 2012, p. 30). Current developed economies are reliant on the unequal, or entirely lacking, valuing of non-developed economies and ecologies, demonstrated, for example, by sending our waste to the third world (Pickin, Donovan & Joe, 2021). If "the context is not exterior to the question" (Butler 2001, p. 6), then the answer to whether rematerial practice is a viable response for Australia, cannot be separated from whether it is a viable response for the other nations our practices impact upon. Through this lens, rematerial work is not only environmentally superior, it relieves serious social inequalities, whilst producing quality and desirable design outcomes.

While producing new 'green' materials through recycling is part of the solution, it has been given too high a pedestal, and does not remove the problem of what we do with these materials when they too become 'rubbish'.

> *"...even doubling the global circularity average of 8.6% to 17% could close the emissions gap by 2035, a gain far in excess of that... [from the] implementation of the Paris Agreement. Clearly, the circular economy is worth implementing." (Crocker et al., 2021)*

Digital modelling of used components has a positive waste trading market development role to play in this. As Laura Tuck from the World Bank puts it: "It doesn't have to be this way" (Kristyn Schrader-King 2018).

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Appendices

Appendix 1: List of Case Study Projects and Corpora Sources

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Appendix 2: Design Goal Assessment Measures

Design objectives:	Assessment measures:
1. enhances quality of life and culture of occupants	Documented client/ community responses
	Improved amenity eg. sanitation, facilities, ventilation
	Enriched or increased appropriate cultural representation or functionality
	Enhances 'liveability'
2. Is aesthetically attractive	Documented client/ community responses
	Sector appraisal / recognition
	Awards / tender selection
3. creates atmosphere	Documented client/ community responses
	Sector appraisal / recognition
	Awards / tender selection
4. meets functionality objectives	Can the space be used for its intended purpose?
	Can the space be used for its intended purpose moreso than it could before the rematerial project was completed?
5. contributes to occupant pleasure and wellbeing	Documented client/ community responses
	Improved amenity eg. sanitation, facilities, ventilation
	Enriched or increased appropriate cultural representation or functionality

Appendix 3: Evidence regarding Design Outcome Achievements

Table 3

Evidence from Corpora regarding Design Outcome Achievements

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive?		creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
				evidence		evidence		evidence		evidence		evidence
St Anna Monastery Residential Complex	1a	no	yes	clearly contemporary, referencing styles of past eras, articulated a new perspective	unsure		yes	aura, alienation, confusing	unsure		yes	enriching
	1a	yes			unsure		unsure		unsure			
	1a	unsure			unsure		unsure	magic, fetish	unsure			
	1c	yes										
	1b	yes	yes	goal to ensure harmony between the monastic domain and the new family residences, rather than to split the distinctive complex into new and old, reminder, spolia, interplay between the old and new, heritage-listed part of the building remains almost unchanged	yes	significant character, Halls up to 4.5 metres high	yes	Halls up to 4.5 metres high	yes	generous stairwells, flexible floor plans grant the occupants considerable freedom, unconventional spatial organisation,	yes	flexible floor plans grant the occupants considerable freedom, high degree of heat insulation

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?	evidence	aesthetically attractive?	evidence	creates atmosphere?	evidence	meets functionality objectives?	evidence	contributes to occupant pleasure and wellbeing?	evidence
Pittsburgh Glass Center	2a	no	yes		unsure		yes		yes	reduction in energy consumption p30,	yes	p34, improve the entrance of sunlight and maximize natural ventilation,
	2b	no		a vital part of this cultural sea-change, offer public access, spur economic recovery, a vital force in the... cultural community, strengthens the region's creative draw and economic potential, a more vital arts community								more connectivity
	2c	yes								comprehensive open studio, accessible and observable		fostering greater interaction, naturally ventilated, extensively daylit
	2c	yes										
	2d	no		The impact of the Pittsburgh Glass Center with regard to urban revitalization cannot be understated... for its long-term contribution toward the stability and vitality of its urban neighborhood, both a regional institution and a national draw, exterior porches that increase connection to the community,		landscaped to provide shade and habitat, attract birds and insects, signature image, resonates with the finish of materials		community nature, draw people in, attract songbirds		state-of-the-art, sustainable principals and LEED requirements were written into a memorandum of understanding with the neighborhood residents, In addition to providing classes exhibitions and working studios for glass , accessible rampartists the		comfortably wander, sheltered entry space, meets the Energy Star(r) cool roof criteria, landscaped to provide shade and habitat, attract birds and insects, control dust, access to operable windows,ventilating locations with high heat loads, Avoid carpet in areas that are susceptible to moisture

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive?		creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
			evidence		evidence		evidence		evidence		evidence	
			crushed limestone reduces the project's contribution to the urban heat-island effect, only very low or no-VOC paints, new building materials... 67% were manufactured within 500 miles of the project. Of these 55% were also harvested or extracted within 500 miles of the site, achieving green building goals, history of the making and renovating should be part of the look of the place,						seminar room is used regularly for after-school drawing classes for neighborhood at-risk children as well as for other nonprofit organizations to hold meetings, increase daylighting, eases maintenance and promotes long-term flexibility, supports relocating equipment modifying plumbing and electrical distribution and even moving walls, providing for the most flexibility in room layout, facilitates flexibility,		intrusion, 82% of the building's interior is daylit, ventilation system, increase daylighting,	
Azkoitia Municipal Library	3a	no	yes	writer, references the site's history	unsure	writer, intentional contrast conceived so as not to compete designer, use of the aged wood	yes		yes		unsure	

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
				as the facade material allows the architecture and park to relate, precisely because of its natural condition			
	3b	no	conserving the rooted memory	sculptural	conjures an image	much more efficient interior	establishes a connection between the building and nature
	3c	yes					
	3d	yes	dignifies the facades of the old station	irregular sculpture	urban palace air, eerie feeling, evokes the history of the building	added the great versatility and flexibility	
	3e	no	p40, recall the building's previous use p42, closer relationship with the surroundings, strengthen the links with the park	p46, sculptural volumes	p42, particularly striking	p42, provide disabled access,	p46, material could be recycled without risk on a long-term basis
Racine Art Museum	4a	yes	yes revitalizing a downtown community, one of the top-ten cultural attractions in Wisconsin	unsure allowing natural light to subtly illuminate the surface of the	yes lantern-like glow	yes	yes

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive?	evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
				r e	building, causes the building to glow in the evening			
	4b	yes	cultural icon, revitalization			pulls the public into, inviting	carefully lit	
	4c	yes				luminous icon		
	4d	no	enhanced… the city			signature vertical richness	luminous flowing spaces	multiple views
	4e	no						
	4f	no				p64, austere but welcoming, stands out on account of its visual simplicity	p64, one of the most highly regarded manual arts centers in the United States, fluid spaciousness p68, reduce the building's environmental impact, ideal setting for exhibitions	p68, full advantage of sunlight
Museum of Automation	5a	no	y e s establish relationships with traditional types, makes the building recognizable	u n s u r e		y e s evoke the… medieval, stimulate visitors' memories	y e s allows visitors to devote their attention to the museum contents, a single free-flowing space, a chained sequence of different zones connected by the interstitial spaces	y e s an optimum relationship between built mass and open space, establishing links with the place, a visual cross-connection

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
	5b	no	p74, creative allusion to the world of cars on display inside p78, a desire to link the history past and present, setting is connect to today's industry	p76, a modern fortification p78, light wells	p76, impressive cylindrical volume, like a perforated fortification evoking the watchtowers of the castles in medieval Castile p78, great scale, warning about the future, the recyled metal...is intended as a salutary reminder of the need for a sustainable automobile industry	p76, auditorium, exhibition area, space devoted to research p78, light wells	p78, can be explored without interruption
1603 Random Road	6a	no	unsure	unsure	yes	yes fully accessible in accordance with ADA (Americans with Disabilities Act) standards	
House	6b	no	re	re p134, distinguised by creative experimental use of materials	p136, spaces that are hidden or revealed by light, filtering sunlight into the interior, luminous atmosphere	p132, accessible p134, efficient sustainable building p136, suitable proportions, simple and flexible	

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?	evidence	aesthetically attractive?	evidence	creates atmosphere?	evidence	meets functionality objectives?	evidence	contributes to occupant pleasure and wellbeing?	evidence
Studio 320	7a	yes	unsure		yes		yes	warm interior	yes		yes	
	7b	yes							yes	designed to last, durable finish	yes	can now be enjoyed at night, fully insulated to current international code, materials have been chosen to nearly eliminate toxic off-gassing
	7c	no		p146, enjoy the starry nights		p140, attractive design, merge the structure with its setting p146, magical refuge		p146, delightful refuge, dispel any sense of coldness		p142, constructions are nomadic... can change the placement very easily, used comfortably, useful... in demographic density		
Big Dig House	8a	no	yes	unique home	yes		yes	unique and interesting, wonderful	unsure		unsure	
	8b	yes							unsure	capable of carrying much higher loads than standard building materials	unsure	large scale planted roof gardens
	8c	no										
	8d	no				striking, elegant and modern, elegantly clad, clean and modern		an exciting backstory		equipped the house to take on a much heavier load than standard building materials		elaborate roof garden

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
	8e	yes		wow factor			
	8f	no			exhilarating		
	8g	no					
	8h	no	realizing the... system	industrial, yet beautiful			
	8i	no		p164, original p168, beautiful garden			p168, thermal insulation, excellent insulating properties
Trailer Wrap	9a	no	yes	unsure	yes	yes	yes
	9b	yes	open, expansive example of small-scale architecture		blown away	advantageous solar orientation for the passive hot-water heating system	privileges experiential conditions that affect the immediate scale of human occupation, high ceiling of the interior extends out to define and incorporate the occupiable landscape, allowing for indirect lighting through the expanse of clerestory windows
	9c	yes	rehabilitated into a contemporary and affordable American house and home, improve the spatial and material quality, the energy efficiency, the		rich, warm floor	facilitating optimum snow melt conditions	layered inside/outside connections, interior spaces filled with natural light and air, soft, indirect lighting through the expanse of clerestory

Project Name	authored by designer?	enhances quality of life and culture of occupants?	aesthetically attractive?	creates atmosphere?	meets functionality objectives?	contributes to occupant pleasure and wellbeing?
#		evidence	evidence	evidence	evidence	evidence
		environmental quality, the psychological context, and the social and behavioral consequences of an abandoned and debilitated trailer house through its reconstruction and rehabilitation, a new vision of the ordinary trailer house that would transform people's stereotyped view of the value and usefulness of this uniquely affordable American housing type, reminiscent of the screen porches of traditional homes,				windows, allow the users to transform its unique spaces into their distinctive home
9d	no		p176, loft opening onto nature		p174, enlarged the volume	p174, introduced more light inside p176, allow light into the central area, takes advantage of the good climate
Duchi 11a	no	u n s u	y e s	p146, the use of recycled material is not evident p148, simple and	y e s p147, evoke specific worlds p149, tempts customers	y e s p148, multifunctional, displaying, paying p149, multiple functions, better screening of available products, eases work,	y e s	p149, soften the spatial division

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
			re	striking elements p149, complex organic shape		permit a fluid effortless exchange between customers and personnel, a convenient place	
	11b	no					
	11b	yes					
	11c	no				shoe storage system that has been integrated with the fitting area, on show	
	11d	yes				combines storage and selling space	ergonomic
	11e	no	p222, reminiscent of the traditional shoe shops	p220, original p222, very recognizable look	p222, particularly radical and eye-catching	p222, took full advantage of the available space, integrate the storage into the shop itself thereby saving space p226, try on shoes, walk in the shoes	p226, rest their feet
Headquarters of the Asociacion	12a	yes	yes sustainable cultural and social experience, opening the campus to that neighborhood, social asset	unsu	unsu	unsu	unsu
	12b	no	p256, social cultural and educational dimension	re	re	re	re

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive?		creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
			evidence		evidence		evidence		evidence		evidence	
Aula Abierta (Open Classroom Association)												
Space of Waste	13a	yes	u	y	architecturally	y						
	13b	yes	n	e	striking	e						
	13c	yes	s	s		s						
	13c	no	u		p284, attractive		p284, dynamic					
			r									
			e									
Tourist Circuit in Flydalsjuvet	14a	no	y	an homage to an old local building tradition preserved for the future	u	floating on a modern glass construction						
			e		n							
			s		s							
	14b	yes		homage to an old local Norwegian building tradition preserved for the future, a traditionally-built timber log building floating on a modern glass construction	u				facilitate toilets and information stands			
					r							
					e							

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
	14c	no	p300, paid tribute to local architectural tradition	p304, visually lighter		p304, information points, public toilets, observation area, parking lot, pathway	p304, allows light to penetrate,
Studio MOA	15a	yes	unsure	unsure	yes attributes of material, spatial, functional, and human attributes to be ambiguous and fuzzy	yes has held exhibitions events performances and forums,	yes
	15b	yes	re the building becomes a vital individual	re we can see different colors of old doors collaging	properties of half solid and half void, "lighter"		
	15c	no		charming	continued to evolve in an evolved state, marvellous, active state	xhibitions, performance arts, coffee shop, and offices	comfortable
	15d	no			unexpected, unusual	a very flexible space which could be ready to expand or even change in function and activities in the future; this is possible because we designed "a method" rather than a space, light and moving walls	safety and comfort, balance between inside and outside, relocate our workspace... depending on the season
	15d	yes					

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive?		creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
				evidence		evidence		evidence		evidence		evidence
	15e	yes										
Officina Roma	16a	no	yes		yes	collage of reused materials	yes		yes		unsure	
	16b	no	s		s	composed as a collage	s	strong visual statement	s		s u	
	16c	no				three-dimensional collage, recycled conception is readable, colourful ceiling, visual focal point				simple in its layout	re	abundant level of sunlight enters
	16d	no		a community approach befitting the educational philosophy						main workshop area, kitchen and bedroom		
	16e	yes		speaks of deadlocks, interdependencies and the need for more fundamental and tougher negotiations over privileges in our future society		composed as a collage,		radiates an atmosphere of urgency		sleeping room, a kitchen and a work shop		
LE	17a	no	un		un		un	attracted	ye		un	
OREC	17a	yes	n s u		n s u		n s u		s	amazing material, regained its original function,	n s u	
CHIE DI	17b	yes										

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
GIUSSANO (Giussano's ears)			r e	r e	r e		r e
CiWoCo 1.0 Circular live-work housing block	18a	no	u n s u r e outstanding	u n s u r e	y e s	y e s	y e s
		yes		p2, attractive, characteristic element p4, effect on esthetical appearance, interesting esthetical look		p1, flexible floorplans, demountable, polyvalent live-work spaces, flexible use p2, customized floor-plans, maximum flexibility, open, flexible design, environmentally friendly, adaptive, recyclable, excellent energy performance, working space, smart use of the limited space, adding years in lifespan p3, building layers can be changed separately	p1, communal roof garden, biodiversity p2, User-friendliness, shared outdoor spaces, enables... change, higher user-friendliness, more freedom, daylight, wide and green gallery, lively and lush shared outdoor space
	18b						
	18c	no				highly demountable and adaptive character, can	biodiversity

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
						adapt to future changes, material bank, energy reduction (almost energy neutral), efficient land use	
	18d	yes			special access, green 'street in the sky'	shared parking garage, five floors, nine apartments, three terraced houses, own entrance, expressly suitable for multiple functions and for working at home	residents... influenced the design process, collective roof garden, prevention of heat stress, every household can determine for itself
fo(u)r friends Himalaya school extension	19a	yes	yes	yes	unsure	yes	4 new schoolrooms	yes	convenient
	19b	yes	yes	wide-ranging and colourful building exposition		yes		yes	
	19c	no	symbolising the reconstruction	individual, creativity-enhancing architectural style			children can now attend school up to eighth grade		excellent view of the breathtaking Himalayan panorama
	19d	yes		buildings are relatives in size and shape, materials they			a library, a slide, open multi-purpose floor		

Project Name	#	authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive? creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
				evidence		evidence		evidence		evidence
						could not be more differnetly,				
	19e	yes								
People's Pavilion	20a	yes	yes		yes		yes		yes		unsure
	20b	no		largest and most important design event in Northern Europe		attractive quality end result		striking facade		
	20c	yes				colour scheme is natural		recognise your own shampoo bottle		almost no ecological footprint
	20c	no				boasts a colourful facade, bespoke plastic shingles				
	20d	yes		open to all				striking colored tiles		meeting place, hang-out, venue for music and theater
	20e	no								
	20f	yes		centrepiece, design statement of the circular economy		vibrantly coloured interlocking plastic tiles served as striking shingles,		iconic		close to zero carbon footprint, central meeting place

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
				from pastels shades of pink and blue, to a vibrant yellow hue			
Studio for Studio Raw Material	21a	no	yes	unsure	yes Drawing from the stark terrain	unsure	unsure
	21a	yes	yes	yes most beautiful patterns and spots	yes	yes	yes
	21b	yes					
	21b	no					
	21c	yes	working with materials with a firm context to history, culture and geography		express an experience of being immersed in this landscape of a singular material		
Center for Design	22a	yes	yes	yes raw expression	yes	yes passive solar, manage the sun's light and heat, LEED Platinum Certified, Passive House Institute US (PHIUS) Certified (First Commercial	yes exposes a long south elevation, living wall of ferns and begonias, slowly releases the stored heat into the

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive? evidence	creates atmosphere? evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
Research						Building in North America), made with 100 tons of stone tailings, a waste product	building at night, manage the sun's light and heat
	22b	no	designed and built by students	sleek, design aesthetics, Achieves Beauty… design goals,		Achieves… Sustainability Design Goals, controlling the sun's harmful effects, a GPS coordinated control system	on demand
	22b	yes	fit in with the architectural vernacular of the other stone buildings				reducing our artificial lighting requirements
	22c	no		modest structure, aesthetically pleasing, beautifully wrought detail, elegantly and simply composed architecture	glow	a small parking area, exterior stonework was created from cottonwood limestone tailings, reception area and adjacent restrooms, multipurpose conference area	lush
	22d	no				storage room, kitchenette	

Project Name	#	authored by designer?	enhances quality of life and culture of occupants? evidence	aesthetically attractive?	evidence	creates atmosphere?	evidence	meets functionality objectives? evidence	contributes to occupant pleasure and wellbeing? evidence
	22e	no	a response to the emerging culture and support of sustainability			iconic			
	22f	no			one of a kind	iconic		dedicated interdisciplinary workplaces	
Eco-Hawks	23a	yes	yes made with 12,000 lbs. of steel grating found in a local salvage yard	unsure	woven rainscreen, effect of a lenticular printed surface	yes		yes high-bay fabrication work areas, fully daylighted, support spaces and the computer research labs, research space	yes thermal mass, remote operable translucent walls, insulated
	23b	no				iconic		designated areas for computer workstations and prototype testing, High-bay fabrication spaces, allow visitors to view research	
	23c	no			gleaming	will excite students		resource and energy conservation features, Electric vehicle charging stations	showers for those who bicycle, use of low-VOC paints and sealants has lower air-borne toxins
	23d	yes	It is their baby, Working together and collaboration are very unique aspects of this						
	23e	no						LEED Platinum building	

Project Name		authored by designer?	enhances quality of life and culture of occupants?		aesthetically attractive?		creates atmosphere?		meets functionality objectives?		contributes to occupant pleasure and wellbeing?	
	#			evidence		evidence		evidence		evidence		evidence
OTOP roject s	24a	no	y e s		u n s u r e		y e s		y e s	excellent acoustic properties	u n s u r e	
	24b	no		discuss the Public Utility of architecture, possibility of new uses				ultimate transformation of the space				
	24b	yes										
	24c	no										
	24d	yes				finished with a decorative 'rubble-dash' render		a single, monolithic volume		purpose built workshop and performance space		

University of South Australia

Appendix 4: Surveys

Survey One

Survey One: Bespoke Reuse Practitioners

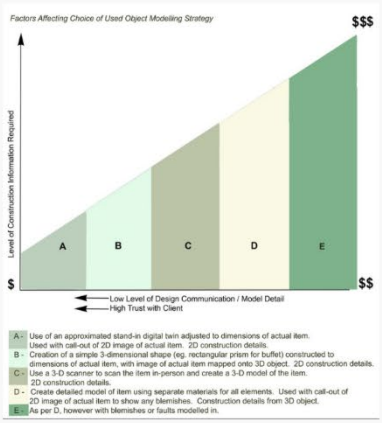
Introduction

As a practitioner/agency identified as having undertaken quality BIM-based bespoke reuse work that may or may not have been physically built, we are asking if you would be prepared to inform research by responding to a brief, anonymous online survey.

I am conducting an honours research project to answer the question *Is BIM-based 'bespoke reuse' one feasible response to Australian construction industry waste?*

By 'BIM-based' I mean that the project has been modelled within a Building Information Modelling (BIM) program such as Revit or ArchiCAD. The term 'bespoke reuse' is used to refer to the incorporation of used, non-recycled materials into design projects.

A draft process for modelling BIM-based interior bespoke reuse is included below for your interrogation via ten questions. I hope that you will consider participating to move the draft model closer to a proposed best practice. The survey will take approximately 10 to 20 minutes to complete.



By completing and submitting the questionnaire/survey, you are indicating that you have read and understood the Participant Information Sheet (see right column) and give your consent to be involved in the research.

This survey is part of a Bachelor of Interior Architecture honours research project being undertaken at University of South Australia.

Participant Information Sheet

The project has been granted ethics approval by the University of South Australia (Ethics number 204147), and the survey meets the requirements of the National Statement on Ethical Conduct in Human Research.

For further information please contact the principal researcher **Roxane Adams, University of South Australia** at adarl001@mymail.unisa.edu.au

Your participation is sincerely appreciated.

Survey One

*Please indicate your profession *
Interior Designer

If 'Other', please state:

*How long have you been working in your current role? *
less than 5 years

If you answered Not Applicable, please explain why:

*Please indicate your employment sector *
Local government

If 'Other', please state:

*In which country do you primarily work? *

*Do you believe you understand what the model above is representing? *
Yes

Optional Comment on the Model:

*Do you believe there are extraneous elements included in this model? *
Yes

Optional comment:

*Do you believe there are steps missing from this practice model? *
Yes

Optional Comment:

*Does this model reflect your own bespoke reuse practice? *
Yes

Optional comment:

If you answered no to the above question, do you see this difference as problematic? *
Yes

Optional Comment:

If not already discussed, what would you change about this model? What is the rationale for this change?

Can you please describe any differences for you in modelling used materials/objects into your digital design, compared with traditional modelling of new items?

*Have you measured the time difference between creating digital designs with new-only products versus including used products? *
Yes

If you answered yes to the above question, what was the outcome?

*Do you know other professionals modelling in used materials/objects into their BIM designs? *
Yes

If you answered yes to knowing other professionals modelling used materials, do you believe their experience/responses would largely agree with your own?
Yes

12. Regardless of whether you have measured this, do you have any comments to make with regard to the time-commitment required to model and provide BIM data for used materials/objects:

PLEASE SUBMIT YOUR RESPONSES.

Thank you

Thank you for completing this survey, your input is highly valued.

If you would like to receive a copy of the honours research thesis, please email adarl001@mymail.unisa.edu.au. Your anonymity will be maintained as the callout for interest is located in multiple places, not only for those invited to complete the survey.

University of South Australia

Survey Two

Survey Two:

Australian Interior Design Community

Introduction

You have been identified as a professional/agency involved in interior design/architecture/construction, and hence may be able to offer 5 minutes of your time to assist with research.

'Bespoke reuse' is an interior design practice that incorporates used, unrecycled materials and/or objects. These materials/objects may comprise a small or large part of the project. I am conducting an honours research project to investigate the question *Is BIM-based 'bespoke reuse' one feasible response to Australian construction industry waste?*

By 'BIM-based' I mean that the project has been modelled within a Building Information Modelling (BIM) program such as Revit or ArchiCAD. The term 'bespoke reuse' is used to refer to the incorporation of used, non-recycled materials into design projects.

BIM-based bespoke reuse includes the process of modelling the used materials/objects into a digital design. This element of the practice is largely undocumented, hence this research. We are hoping you will support the research by responding to a short, primarily yes/no anonymous online survey. It doesn't matter whether you have or haven't been involved in this work before. The survey will take 5 to 10 minutes to complete.

By completing and submitting the questionnaire/survey, you are indicating that you have read and understood the Participant Information Sheet (see right column) and give your consent to be involved in the research.

This survey is part of a Bachelor of Interior Architecture honours research project being undertaken at University of South Australia.

Participant Information Sheet

The project has been granted ethics approval by the University of South Australia (Ethics number 204147), and the survey meets the requirements of the National Statement on Ethical Conduct in Human Research.

For further information please contact the principal researcher **Roxane Adams, University of South Australia** at adarl001@mymail.unisa.edu.au

Your participation is sincerely appreciated.

Survey Two: Australian Interior Design Community

*Please indicate your profession *

Interior Designer

If 'Other', please state:

*How long have you been working in your current role? *

less than 5 years

*Do you primarily work in Australia? *

Yes

*Have you ever incorporated used materials or objects into an interior design project? *

Yes

*Have you ever modelled used materials or objects into a digital design (eg. within Revit or ArchiCAD)? *

Yes

*Do you believe it is prohibitively expensive to model used (and therefore mostly one-off) materials and objects into digital designs? *

Yes

Optional comment regarding expense of modelling used items:

*How long do you imagine it would take to digitally model the set of doors pictured in the right column, into a digital design? *

under 10 minutes

*Would you incorporate used materials or objects into your digital designs if they were already digitally modelled for you (eg. in the way that Caroma products are for example)? *

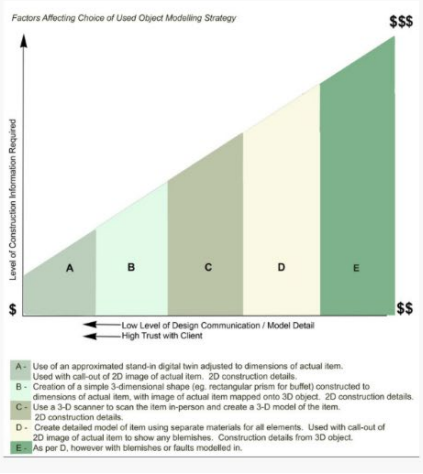
Yes

*Reviewing the model below, do you see this as a feasible practical approach to BIM-based interior bespoke reuse work? *

Yes

Optional comment regarding model below:

PLEASE SUBMIT YOUR RESPONSES



Thank you

Thank you for completing this survey, your input is highly valued.

If you would like to receive a copy of the honours research thesis, please email adarl001@mymail.unisa.edu.au. Your anonymity will be maintained as the callout for interest is located in multiple places, not only for those invited to complete the survey.

Appendix 5: Data regarding case study characteristics

Figure 49

Number of design awards won (aesthetic credentials) by case study projects and envrionment-focused awards won (environmental credentials) by case study projects.

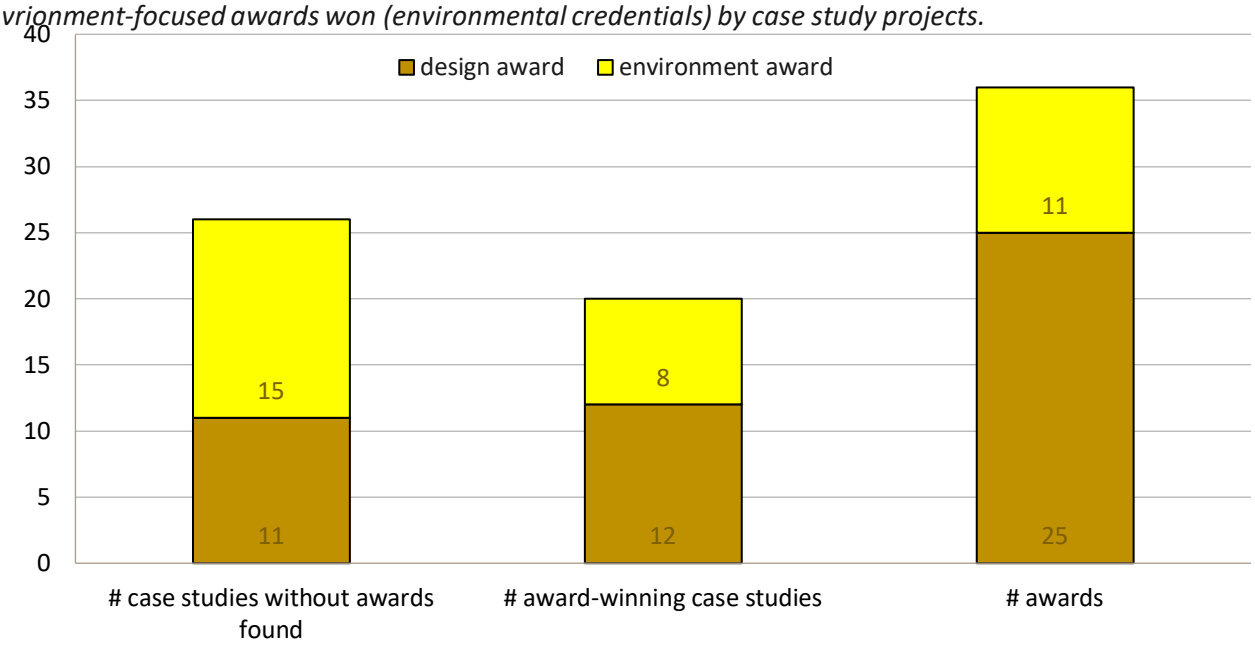


Table 4

Evidence from Google search regarding Achievement of Awards

Case Study	Design Award	Environment Award
Pittsburgh Glass Center	Certificate of Merit 2009 American Institute of Architects Pittsburgh Chapter, Building Excellence Award 2009 Best New Construction Over $10 Million Master Builders' Association of Western Pennsylvania Inc, AIA Honor Award 2003,	Green Design Citation 2009 American Institute of Architects Pittsburgh Chapter, LEED Gold, COTE Top Ten
Azkoitia Municipal Library	1st prize competiton of ideas for the extension de la Bibliothèque Municipale d'Azkoitia, Guipúzcoa	National Award in Sustainable Architecture of the Civitas Nova Forum
Racine Art Museum	2005 AIA Chicago Divine Detail Award – Honor Award 2003 AIA Chicago Distinguished Building Award – Citation of Merit 2003 AIA Chicago Interior Architecture Award – Honor Award	2004 AIA Chicago Sustainable Design Award – Special Recognition for Downtown Revitalization

Case Study	Design Award	Environment Award
	2002 Chicago Athenaeum Museum of Architecture and Design – American Architecture Award	
1603 Random Road House	First Place Award, Association of Collegiate School of Architecture (ACSA) Steel Tube Competition, 2001 Third Place, David Award. Archeworks, Chicago "Excellence in Design for People with Disabilities"	2001 First Place, Design with Memory, International competition for sustainable design
Big Dig House	AIA/BSA Housing Design Award, Metropolis Next Generation Prize,	
Space of Waste	highly commended in the AJ Small Projects Awards	
Studio MOA	"internationally recognized and awarded as a significant example of architecture" ADF Magazine	
CiWoCo 1.0 Circular live-work housing block	Best Practice and Design, Hans Sauer Award 2020, winner ARC19 Innovation Award,	winner Dutch Sustainable Building Awards 2020, winner Hans Sauer Award 'Designing circularity in the build environment'
fo(u)r friends Himalaya school extension	Bronze Prize in Architectural Design Design Educates Awards, first place Hans Benedikt Prize Augsburg University of Applied Sciences, 2020 Brick Award in the "Building Outside the Box" category	
People's Pavilion	Dutch Design Awards 2018 in the category Habitat, ARC18 Innovation Award. nominated for the New Material Award, Hans Sauer Award 2020, Detail Prize 2020	won the Frame Awards 2018 in category Sustainable Design,
Centre for Design Research		Acknowledgement Award in the prestigious 2011 Holcim Award for Energy Efficient projects in North America
Eco-Hawks Research Facility	2014 won the Juror's Choice award in Architizer's A+ Awards in the Student Design-Build Typology Category	
OTOProjects	Turner Prize	Global Award for Sustainable Architecture

Figure 50
Substances, Materials, Objects, Equipment Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

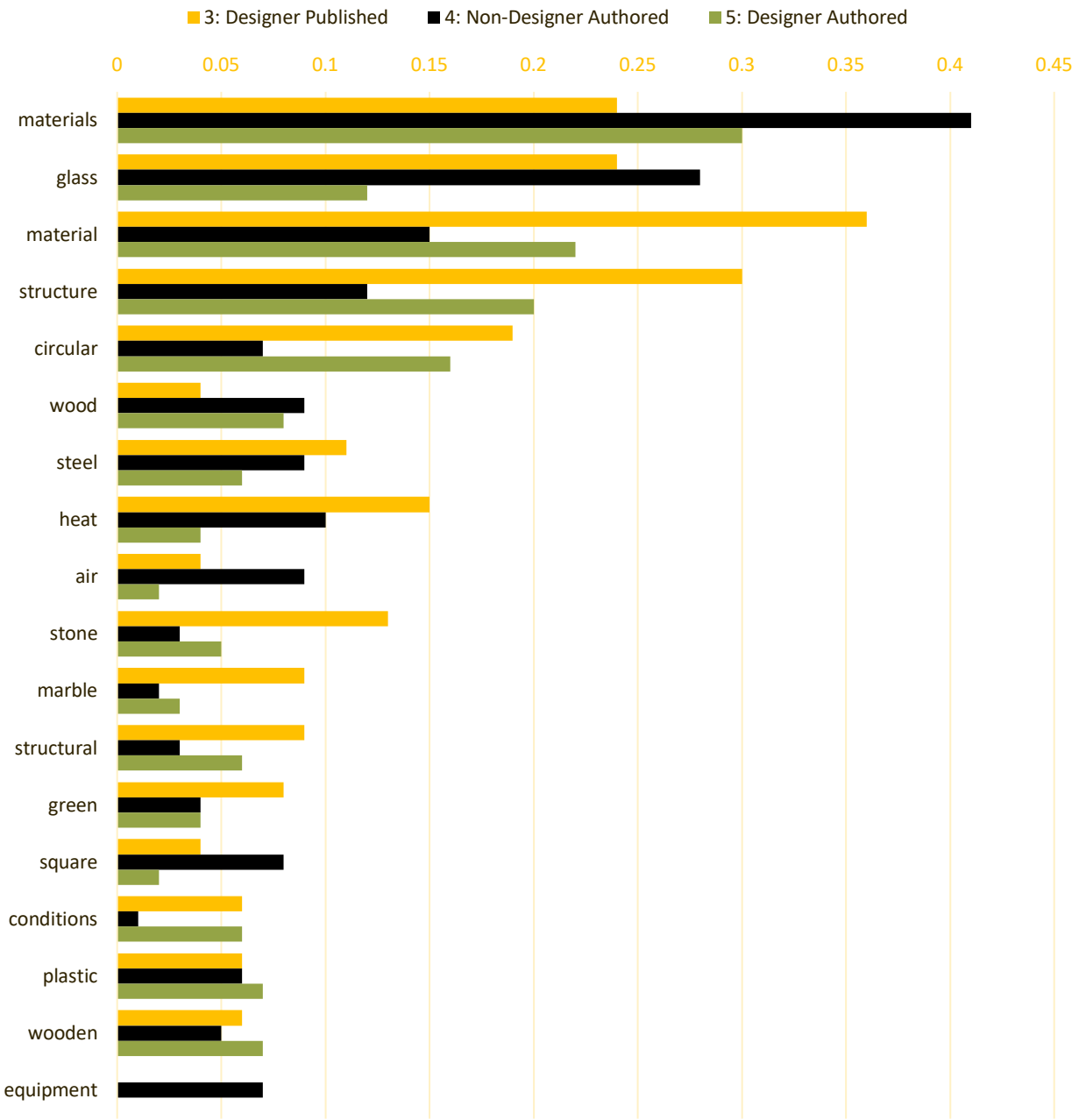


Figure 51

Perspectives on the time required to model door in Figure 13 by belief about expense

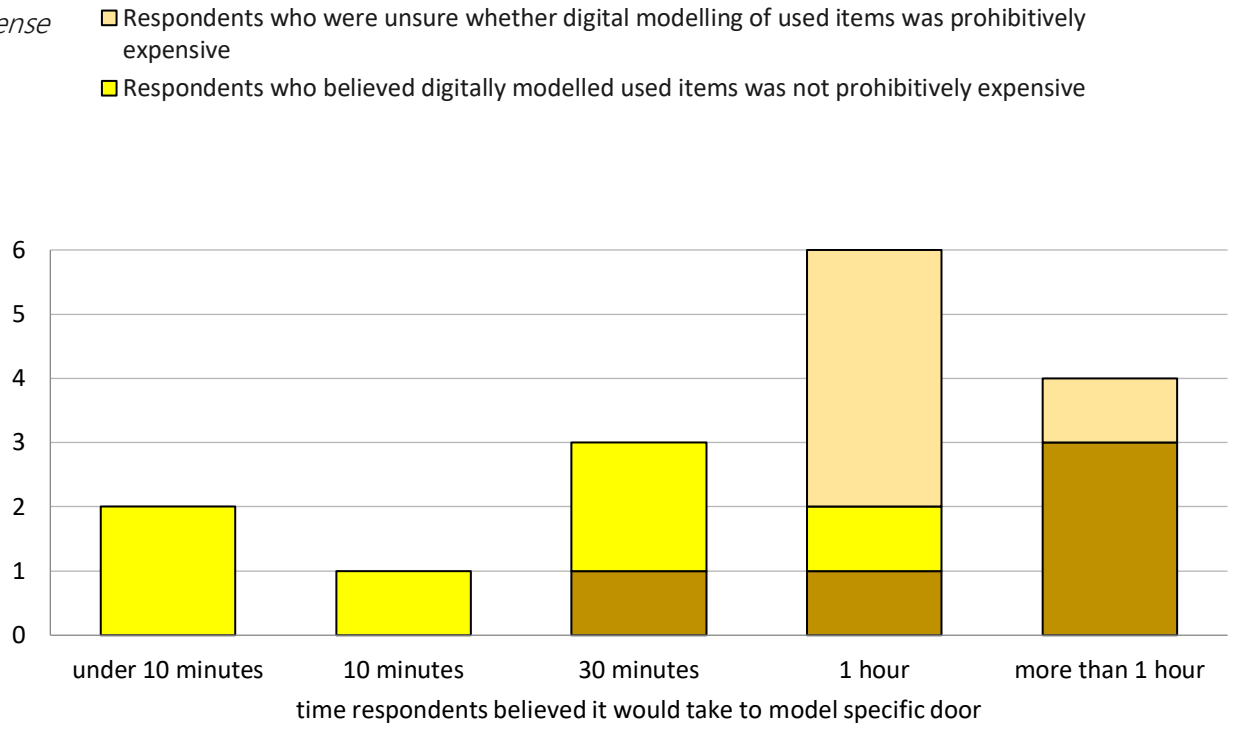
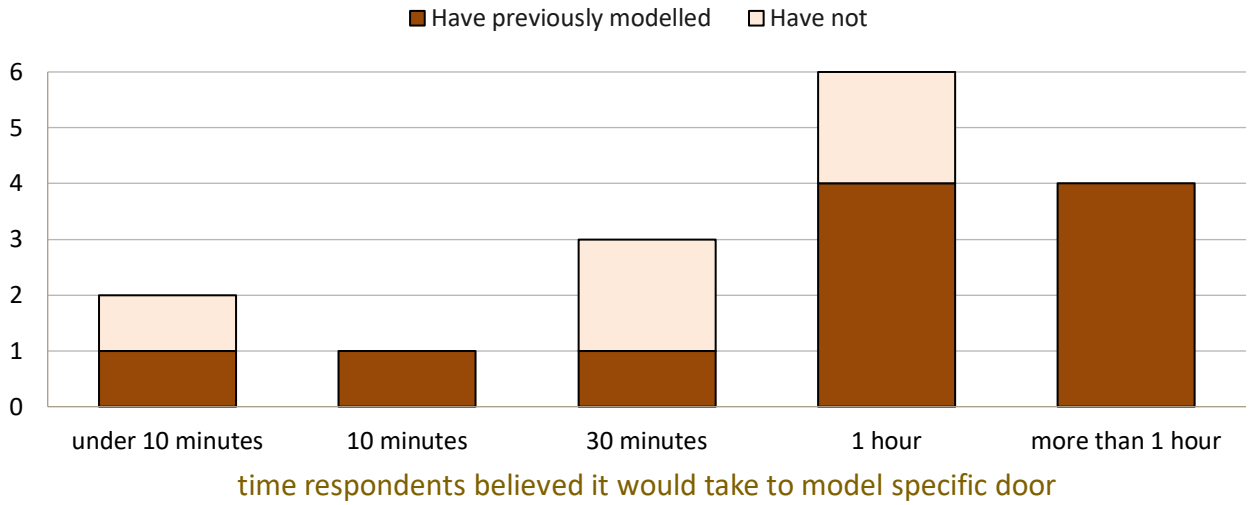
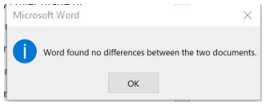


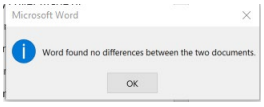
Figure 52

Perspectives on the time required to model door in Image X



Appendix 6: Sample evidence of same text published across corpora





Compared Document

There is no doubt that to make the extension of ~~a library which once served~~preexistence as the ~~railway~~old station~~ the~~ of Azkoitia, is an extremely delicate ~~approach concentrated on conserving the rooted memory of the symmetrical and intricate~~operation. The deep decoration ~~on the building's façade. the sculpted extension takes~~and the good conservation of it, dignifies the facades of the old station, with a certain urban palace air. Despite its small size, the volume which it has to be preserved shows an ~~irregular shape~~,architecture whose symmetry, facades' decoration, corners and ~~clad in~~ roof´s finishes has a clear intention to characterized it. A sculpted box with an irregular shape, takes the new expansion of the library. Its heavy cover made of wooden railway sleepers ~~(referencing~~evokes the history of the ~~railway station). the robust cladding conjures an image~~ building, almost as ~~though~~ ':if when the tracks were dismantled the old sleepers had been stacked near the ~~station'~~station. The box character of the object which has the extension, allows not competing with the preexisting architecture. And at the same time, its condition of unfinished object values even more the current building. Take root.

~~the~~The passant stations of the railway arise, often, as pre-designed buildings, from the board who design for a time all the stations of the route. Its deployment in the place is concentrated more with the railway line even than the city, trusting on the design autonomy. The railway´s disappearance does nothing but to reinforce that uprooted condition. The result is the eerie feeling which produces the library that its location was not a coincidence; and so, it could have been in any other place. It needed to take root.

The extension is located in the south side wall of the old station, ~~purposely~~so that is intended to relate the library ~~to~~with the ~~train´s boulevard. the~~Train´s Boulevard. The use of the aged wood as the ~~primary~~façade material ~~establishes~~, allows relating architecture and park, precisely because of its natural condition. In this way, the new library opts for the boulevard giving sense to its emplacement. Enlargement by emptying.

Before the enlargement, the stairs case, the service´s premises, the access and the control occupy almost a ~~connection between~~third of the building ~~and nature. the architects worked~~surface. The needed enlargement of the uses of the library has been done by the procedure of emptying the existing building from all those uses, so that to gain such area.

With this, are achieved three big diaphanous room of 7x19m whose regular structure allows furnishing and subdividing them with ~~the~~light partitions in infinite ways. To the spatial attractiveness of unify the interior space in a coherent way with the unitary definition of the existing building´s façade, is added the great versatility and flexibility of use which provides the library. In this way, that irregular

Original Document (3b - USER)

in the spanish town of azkoitia, estudio beldarrain completed an expansion of a library which once served as the railway station. the delicate approach concentrated on conserving the rooted memory of the symmetrical and intricate decoration on the building's façade. the sculpted extension takes an irregular shape, and clad in wooden railway sleepers (referencing the history of the railway station). the robust cladding conjures an image as though 'the tracks were dismantled the old sleepers had been stacked near the station'.

the extension is located in the south side wall of the old station, purposely to relate the library to the train's boulevard. the use of the aged wood as the primary material establishes a connection between the building and nature. the architects worked with the irregular geometrics of the structure, therefore the scheme was generated from the inside to the outside.

prior to the project, the staircase, the service's premises, the access and the control occupied almost a third of the building area, through the procedure of demolishing the existing building from all those uses and starting anew, a much more efficient interior was fitted.

Revised Document (3c - USER)

There is no doubt that to make the extension of preexistence as the old station of Azkoitia, is an extremely delicate operation. The deep decoration and the good conservation of it, dignifies the facades of the old station, with a certain urban palace air. Despite its small size, the volume which it has to be preserved shows an architecture whose symmetry, facades' decoration, corners and roof´s finishes has a clear intention to characterized it. A sculpted box with an irregular shape, takes the new expansion of the library. Its heavy cover made of wooden railway sleepers evokes the history of the building, almost as if when the tracks were dismantled the old sleepers had been stacked near the station. The box character of the object which has the extension, allows not competing with the preexisting architecture. And at the same time, its condition of unfinished object values even more the current building. Take root.

The passant stations of the railway arise, often, as pre-designed buildings, from the

Compared Document

When ~~we~~Brininstool + Lynch undertook the design of the museum in Racine, it was with a thorough understanding of the type of art that would occupy it, the environment required for the art, and the knowledge that our design would need to be a pivotal project in revitalizing a downtown community. Our work involved the complete programming and design for the museum, as well as the first exhibitions.

The project is a complete renovation of a composite of several buildings and structures spanning over a century. The design for the new museum redefines the existing structures with contemporary materials and a new spatial composition. The facade is wrapped in translucent acrylic panels separated from the exterior surface, allowing natural light to subtly illuminate the surface of the building during the day, while lighting at the top of the facade causes the building to glow in the evening. The iridescence of the acrylic panels by day and their lantern-like glow by night parallel the qualities of light and movement inside the museum.

Since opening in the spring of 2003 the museum has become one of the top-ten cultural attractions in Wisconsin, exceeding all museum-board criteria. It has received international press attention and four design awards from the AIA – Chicago, including the Chapter's first Sustainable Design Award.

Original Document (4a - USER)

When we undertook the design of the museum in Racine, it was with a thorough understanding of the type of art that would occupy it, the environment required for the art, and the knowledge that our design would need to be a pivotal project in revitalizing a downtown community. Our work involved the complete programming and design for the museum, as well as the first exhibitions.

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Revised Document (4e - USER)

When Brininstool + Lynch undertook the design of the museum in Racine, it was with a thorough understanding of the type of art that would occupy it, the environment required for the art, and the knowledge that our design would need to be a pivotal project in revitalizing a downtown community. Our work involved the complete programming and design for the museum, as well as the first exhibitions.

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Appendix 7: Wmatrix data

Table 1

Top 20 most frequent words in each corpus (minus particles, pronouns) with relative frequency

unique to this corpus's top 20
shared by 2 corpora's top 20
shared by 3 corpora's top 20
shared by 4 corpora's top 20
in all corpora's top 20

1: All text		2: Non-Designer Published		3: Designer Published		4: Non-Designer Authored		5: Designer Authored	
building	0.68	building	0.65	building	0.96	building	0.7	building	0.67
design	0.62	design	0.64	design	0.43	design	0.68	design	0.53
project	0.43	project	0.44	construction	0.41	new	0.42	project	0.46
materials	0.36	materials	0.38	work	0.39	project	0.41	construction	0.37
new	0.36	new	0.36	project	0.39	materials	0.41	space	0.31
architecture	0.31	architecture	0.33	material	0.36	architecture	0.33	materials	0.3
construction	0.28	construction	0.27	space	0.34	studio	0.32	architecture	0.29
space	0.25	studio	0.26	use	0.3	glass	0.28	new	0.29
studio	0.25	space	0.24	structure	0.3	house	0.24	material	0.23
house	0.22	house	0.23	old	0.26	buildings	0.23	structure	0.21
glass	0.21	buildings	0.22	university	0.24	students	0.22	work	0.21
buildings	0.2	glass	0.2	glass	0.24	construction	0.22	house	0.2
students	0.2	students	0.2	built	0.24	centre	0.21	buildings	0.18
material	0.19	used	0.18	materials	0.24	space	0.2	old	0.18
use	0.18	made	0.17	walls	0.24	use	0.19	students	0.18
used	0.18	use	0.17	concrete	0.23	used	0.19	circular	0.17
made	0.17	centre	0.16	waste	0.23	spaces	0.18	concrete	0.17
work	0.17	material	0.16	part	0.21	architects	0.18	different	0.17
old	0.16	spaces	0.16	students	0.19	recycled	0.17	public	0.17
structure	0.16	old	0.15	wall	0.19	sustainable	0.16	use	0.17

Figure 53

Top 20 words in each corpus by relative frequency

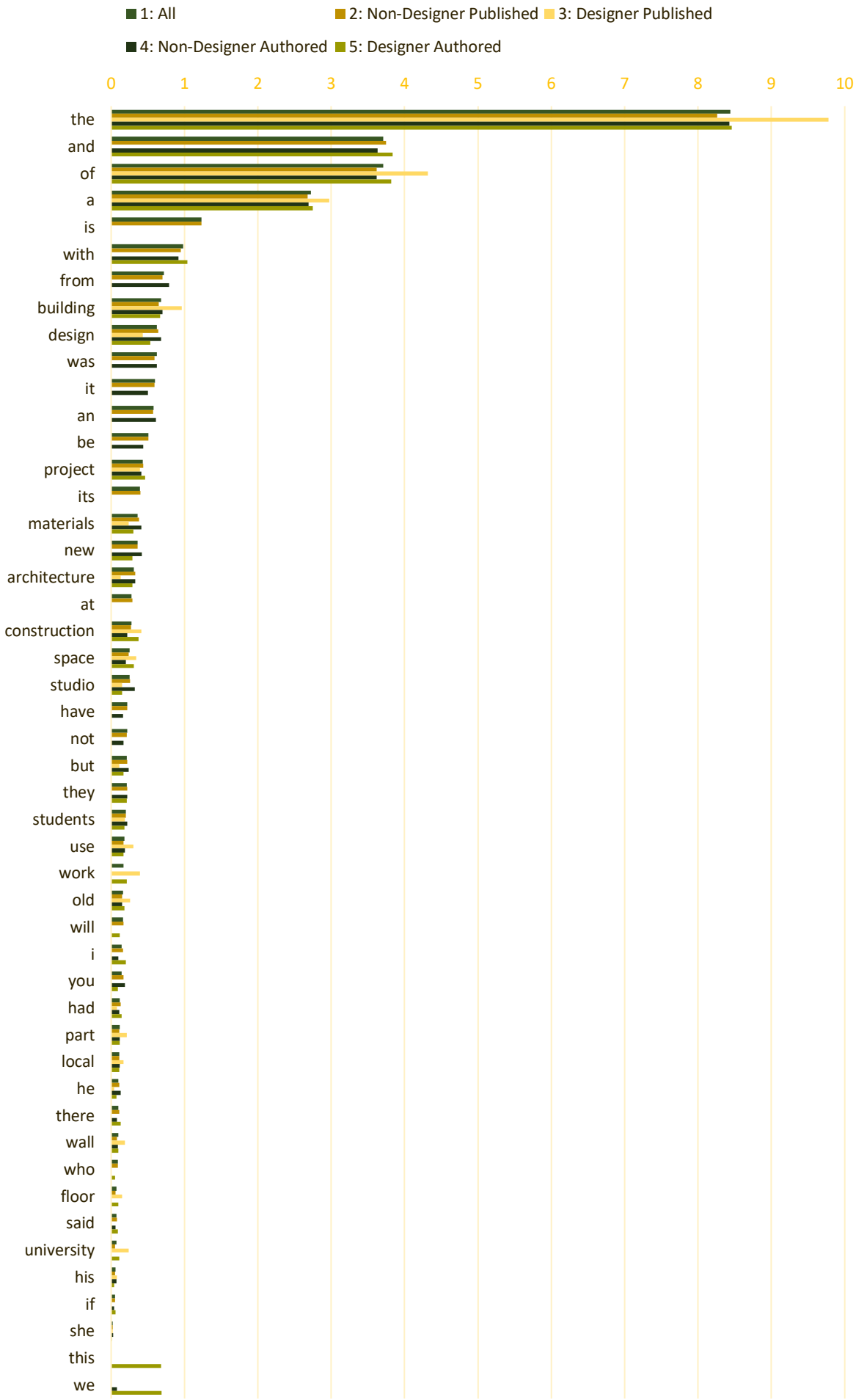


Figure 54
Top 10 multi-word expressions in each corpus by Relative Frequency

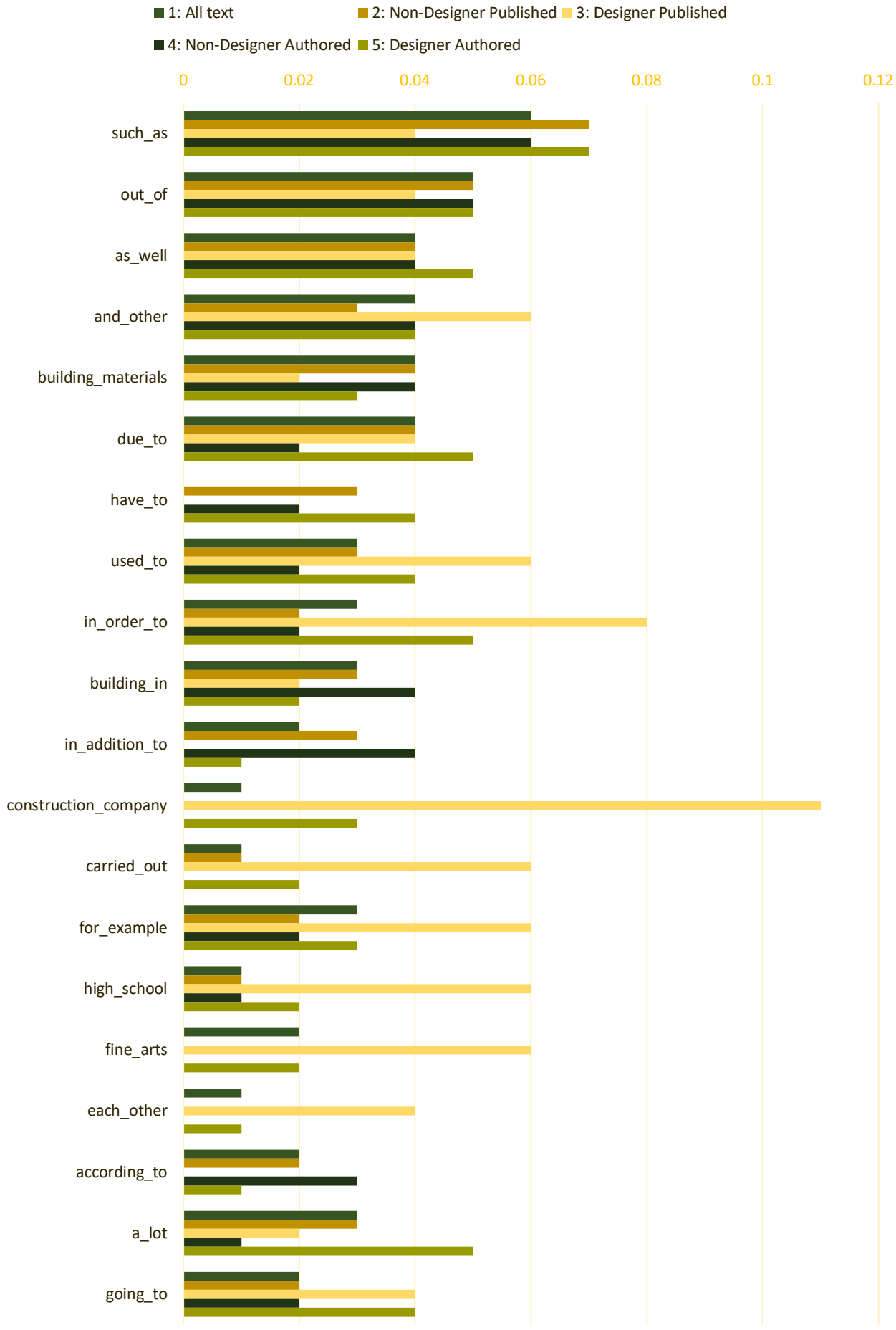


Figure 55

Top 10 words in Corpora 3, 4 & 5 by relative frequency.

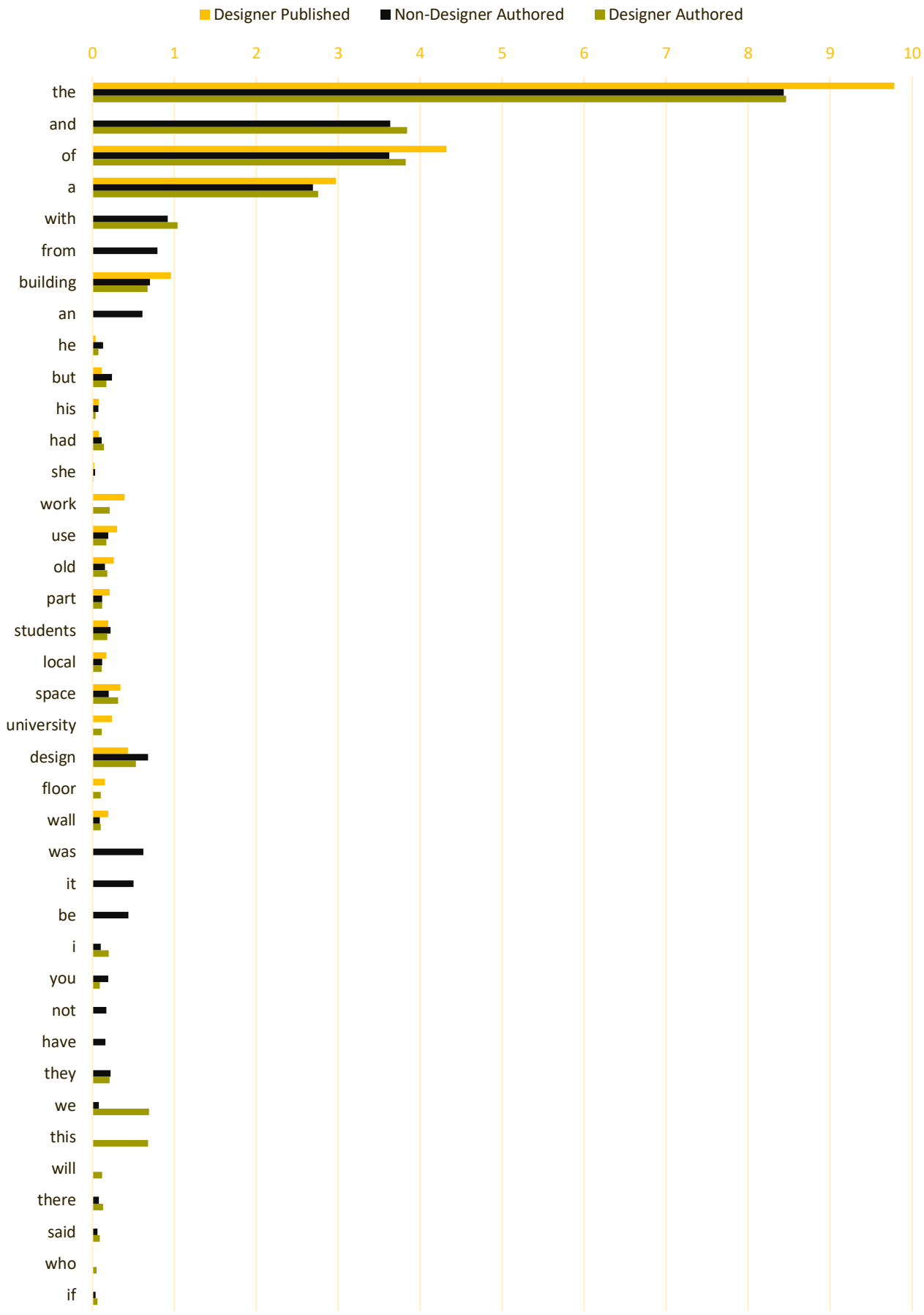


Figure 56

Top 10 multi-word expressions in Corpora 3 & 4 by Relative Frequency

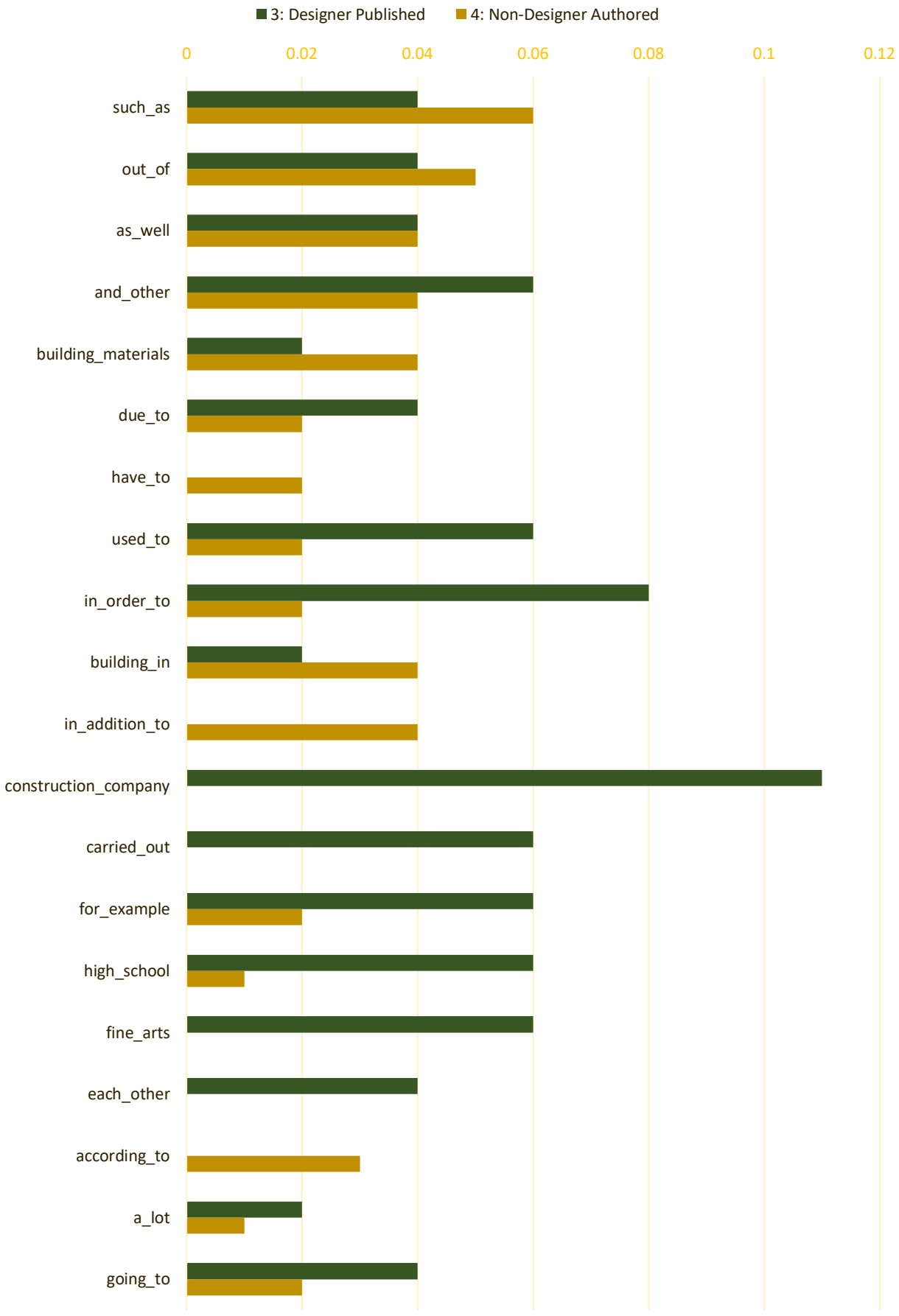


Figure 57

top 10 Arts and Crafts Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

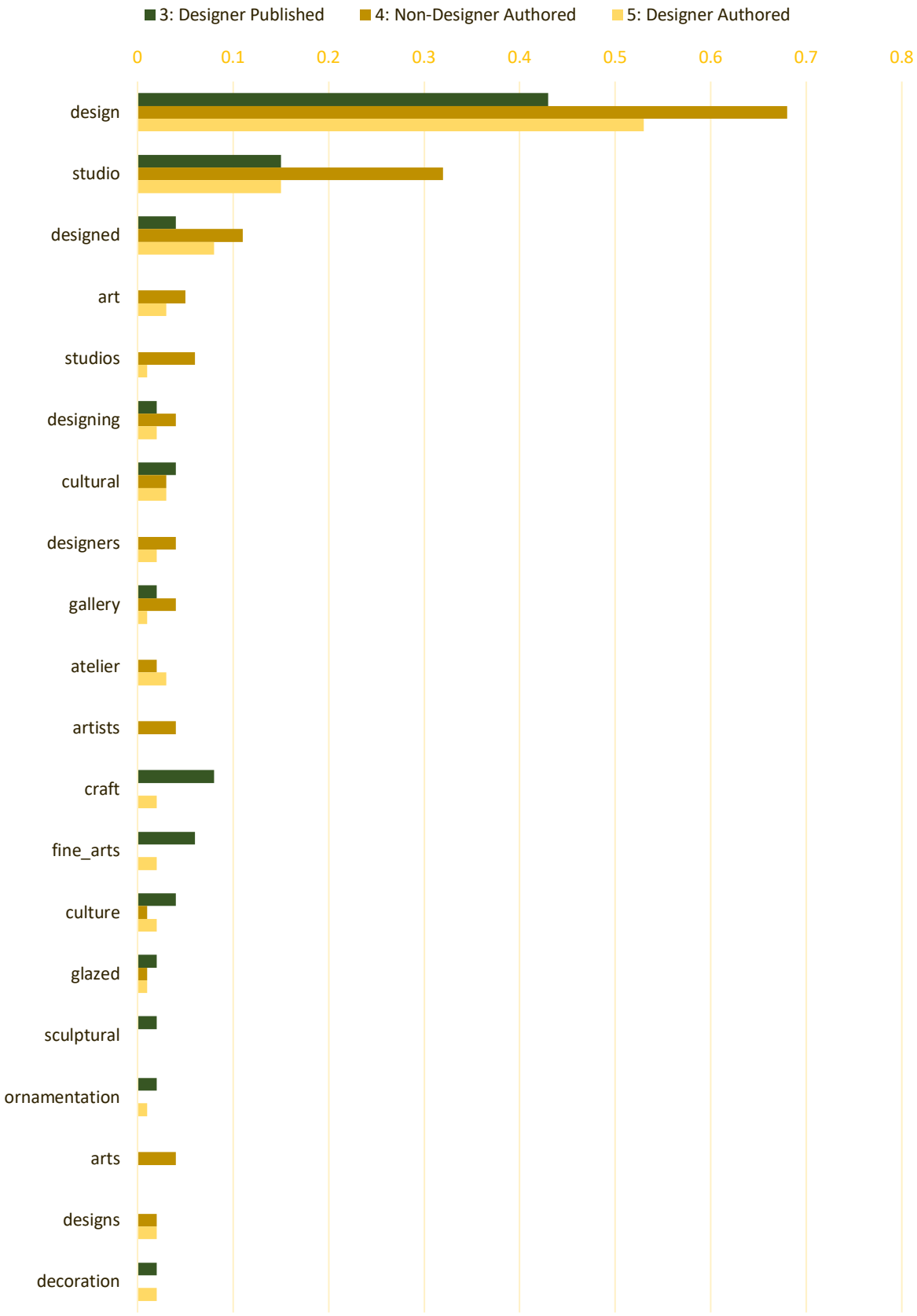


Figure 58
top 10 Architecture Semantic Category. Top 10 by Relative Frequency

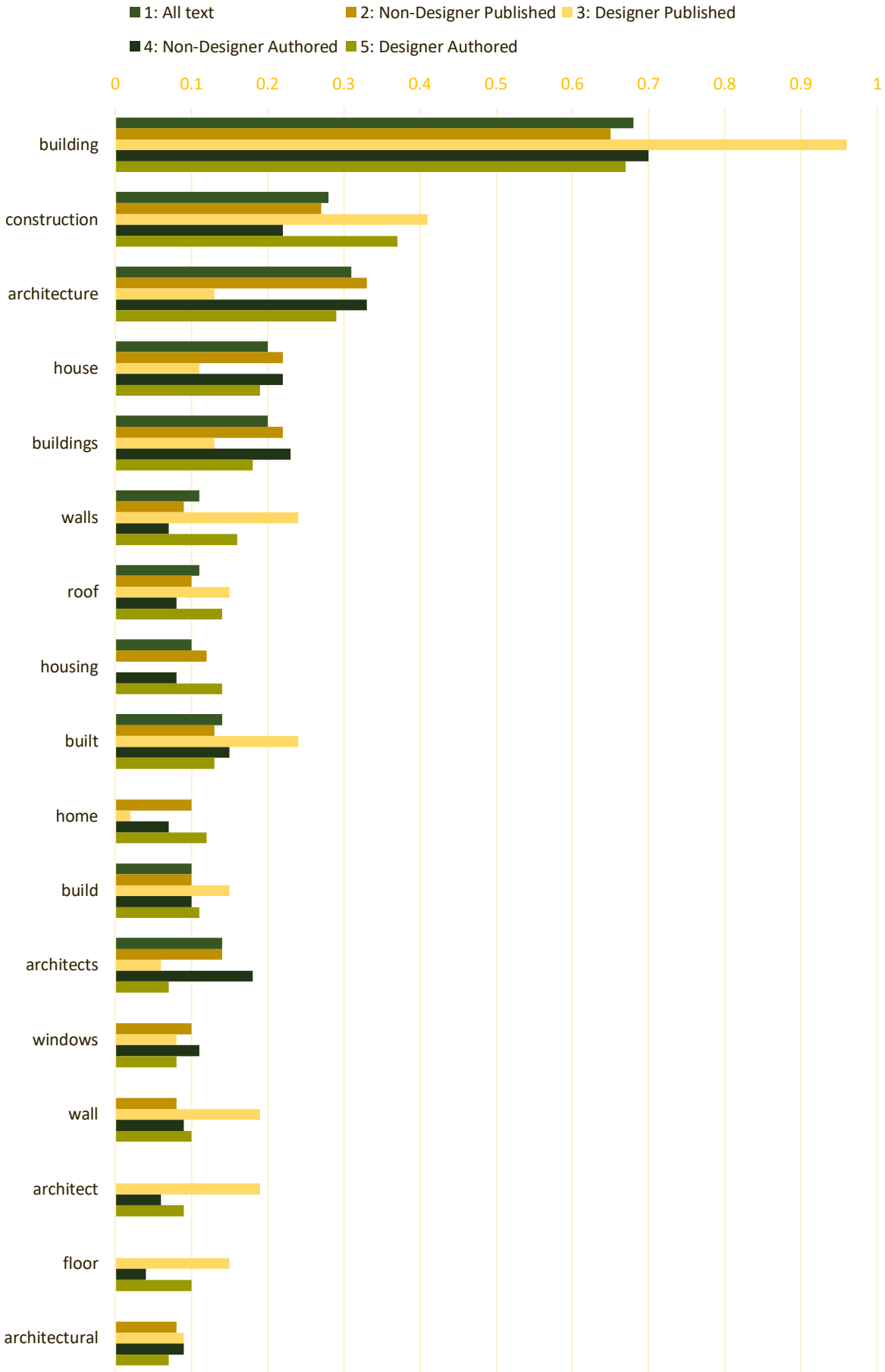


Figure 59

Semantic Concepts Top 10 by Relative Frequency

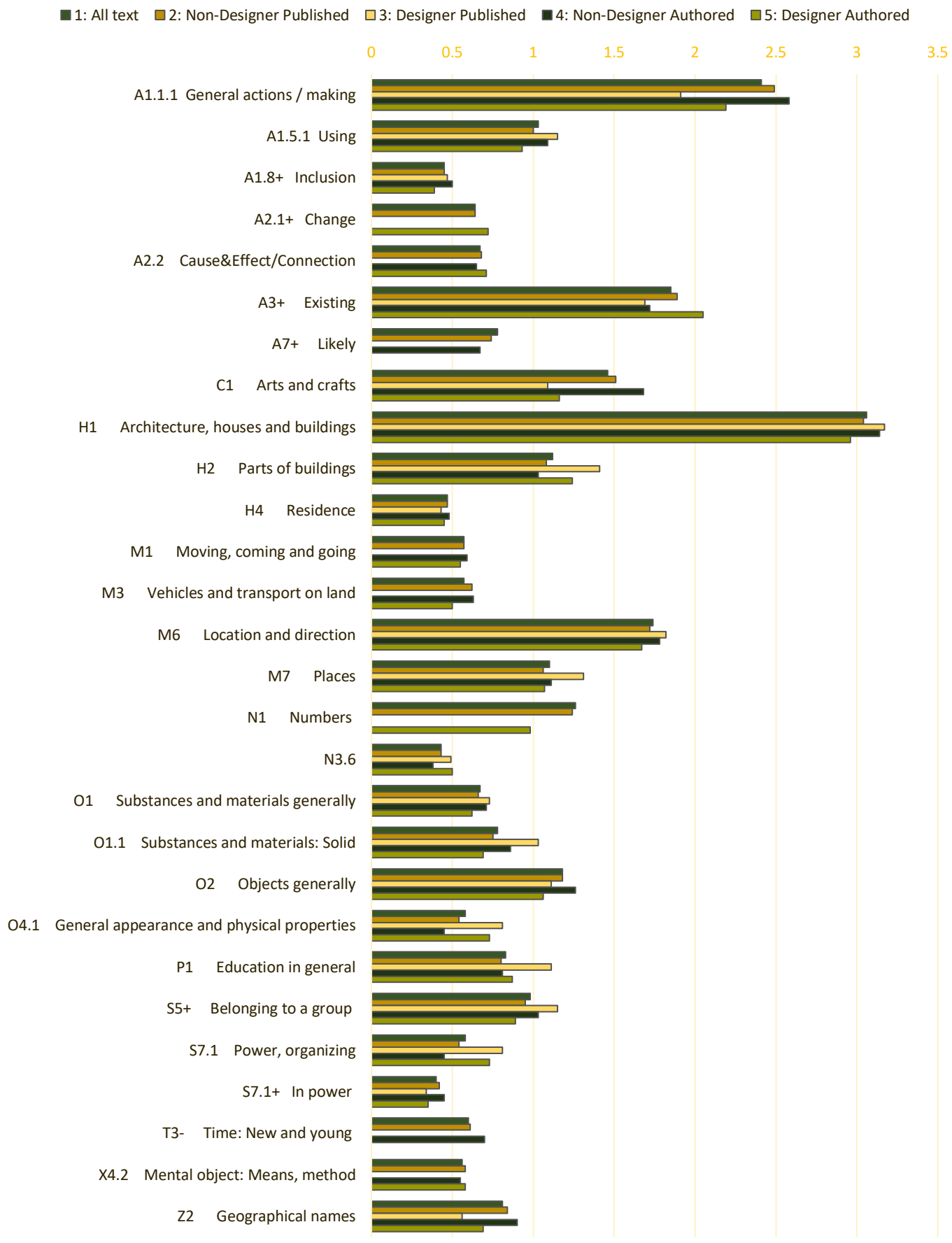


Figure 60

Architecture Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

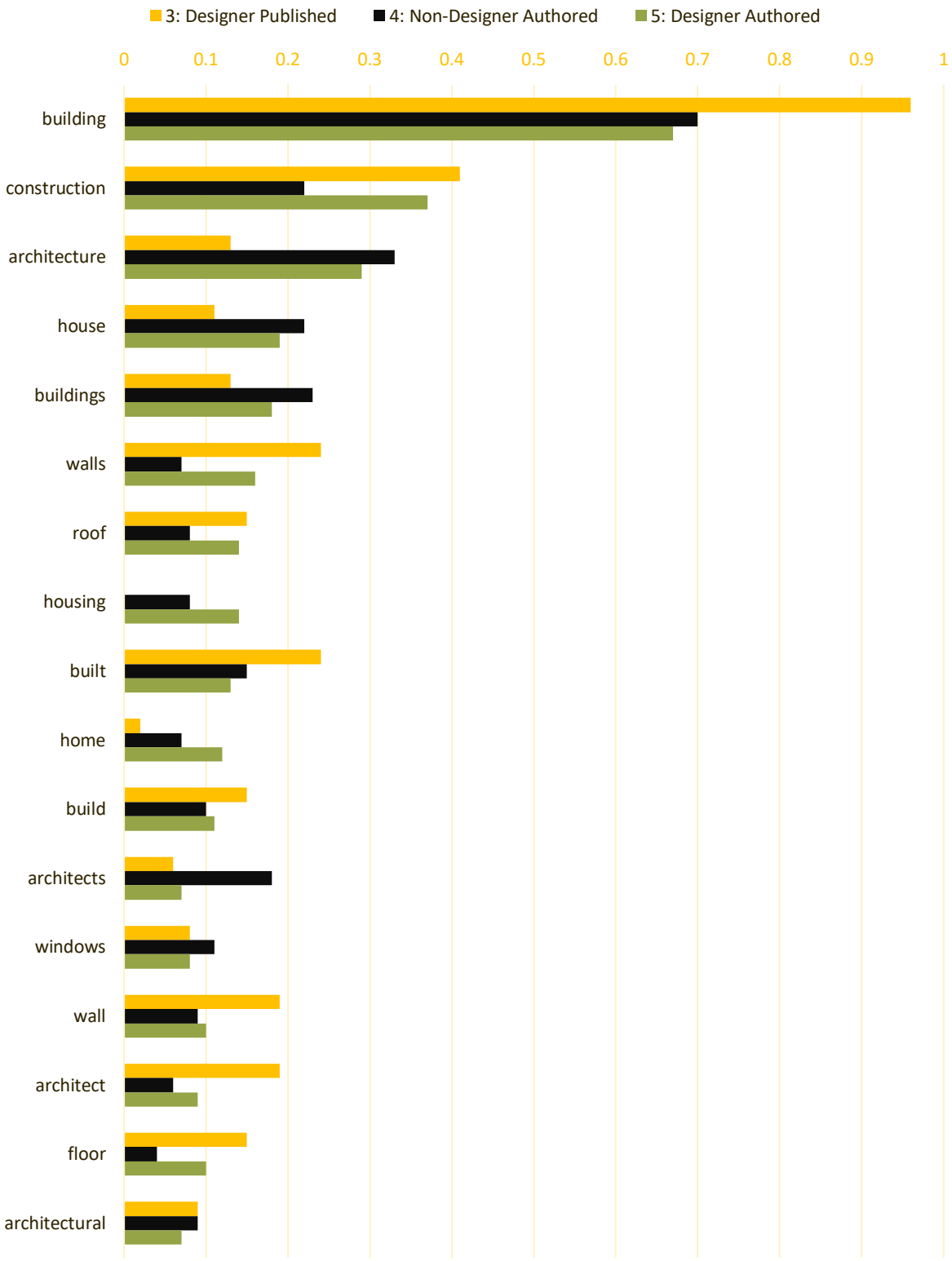


Figure 61

Time Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

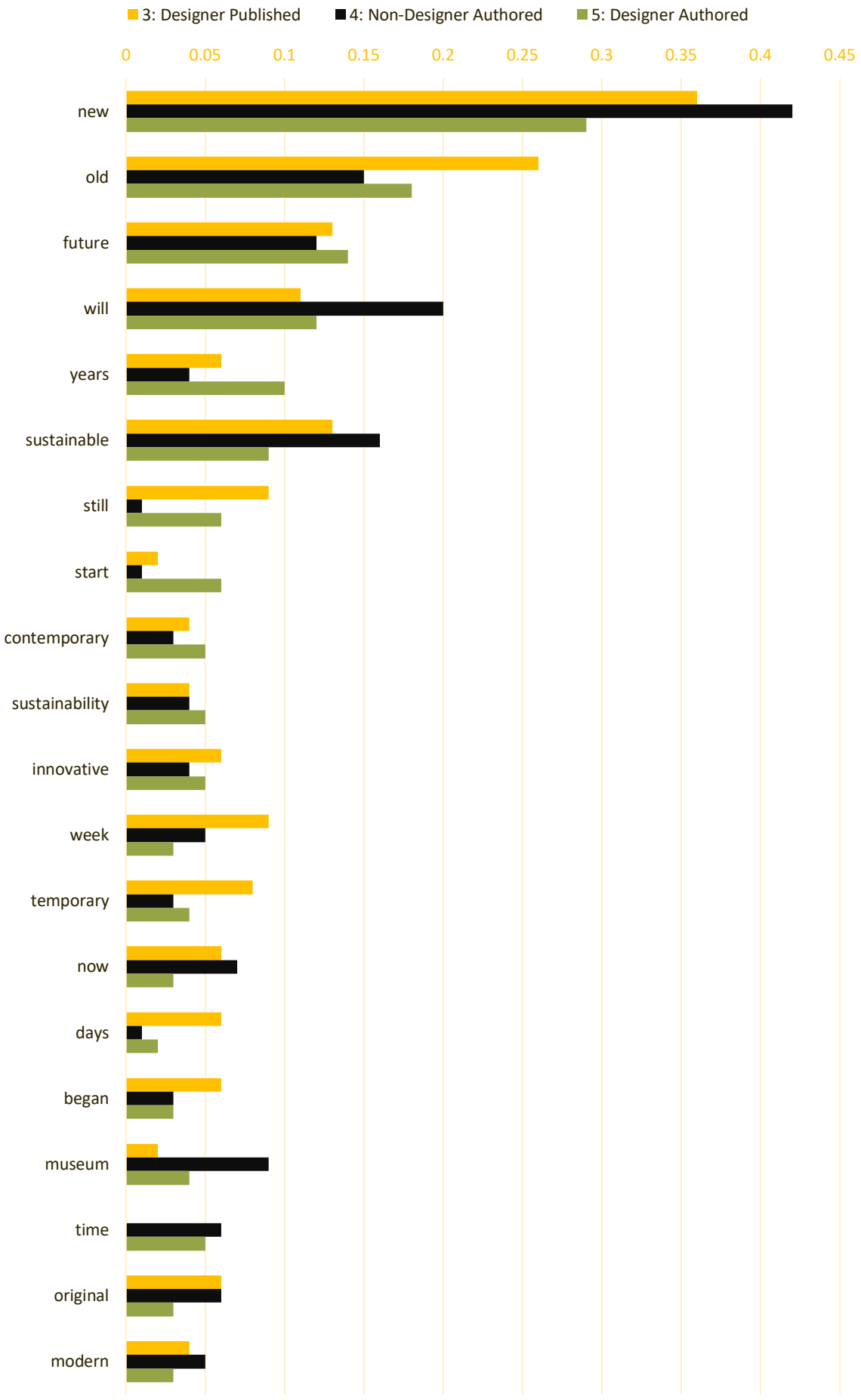


Figure 62
Semantic Concepts. Top 10 in corpora 4 & 5 by Relative Frequency

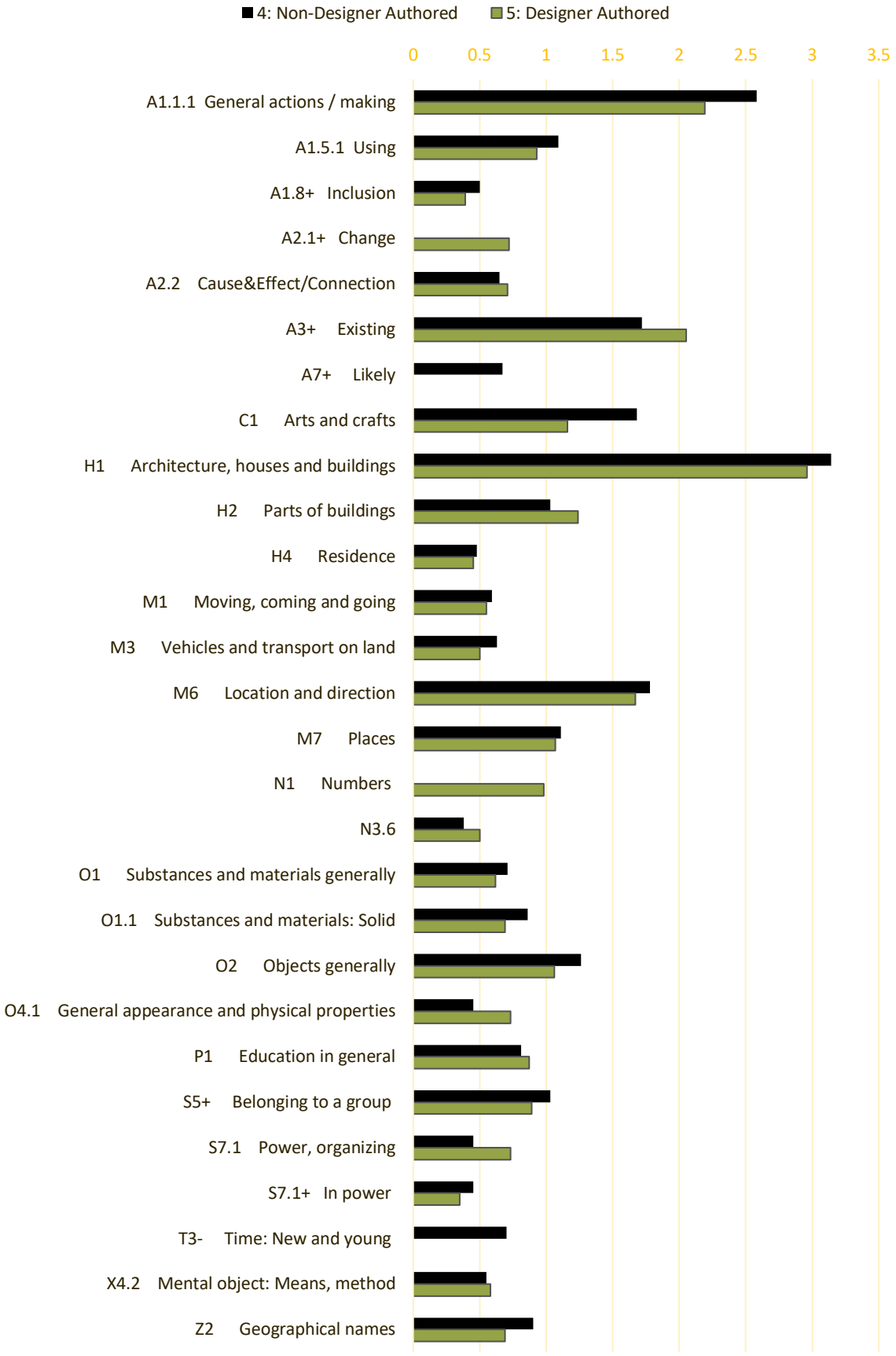


Figure 63

Semantic Concepts. Top 10 in corpora 3 & 4 by Relative Frequency

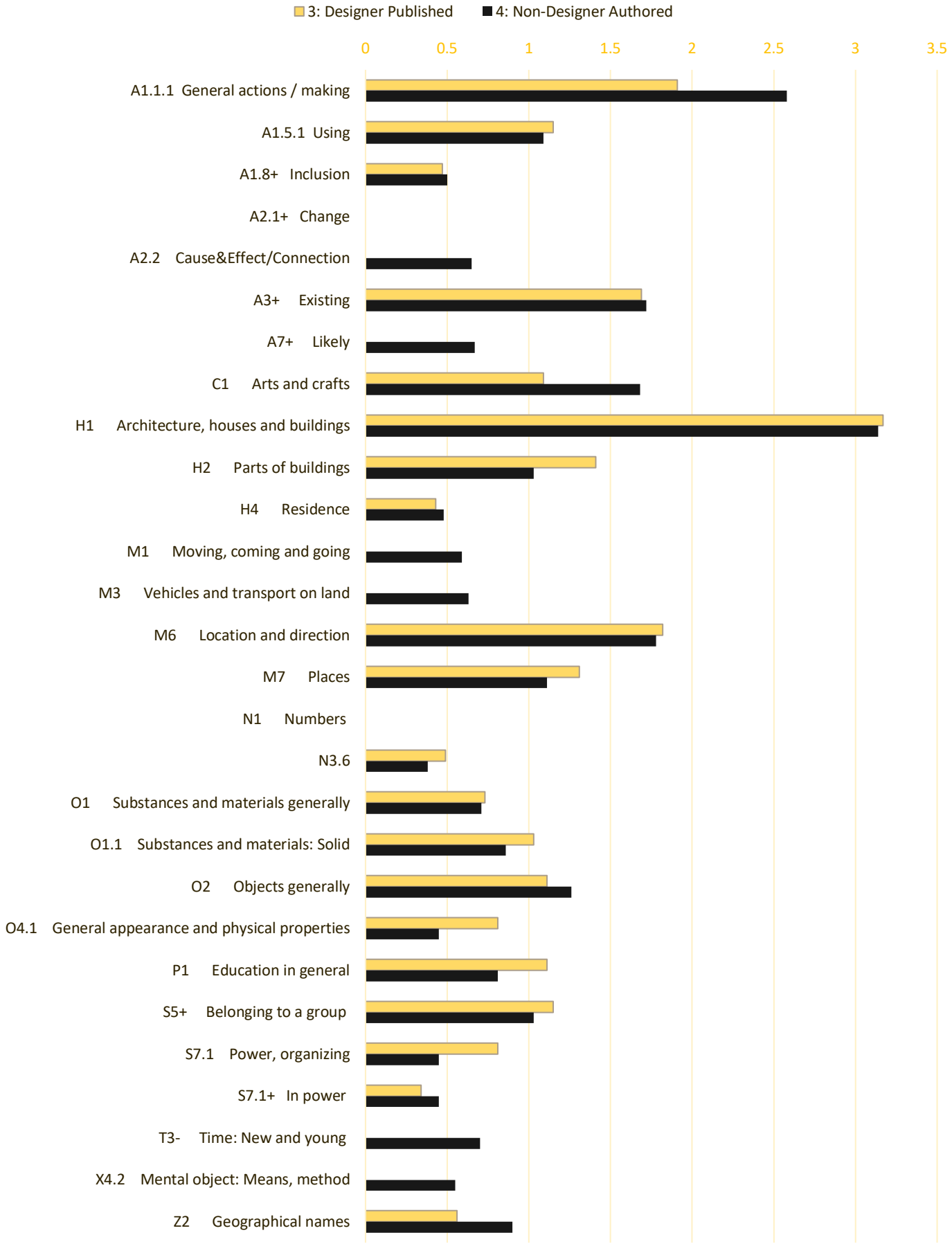


Figure 64
Language and Communication Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

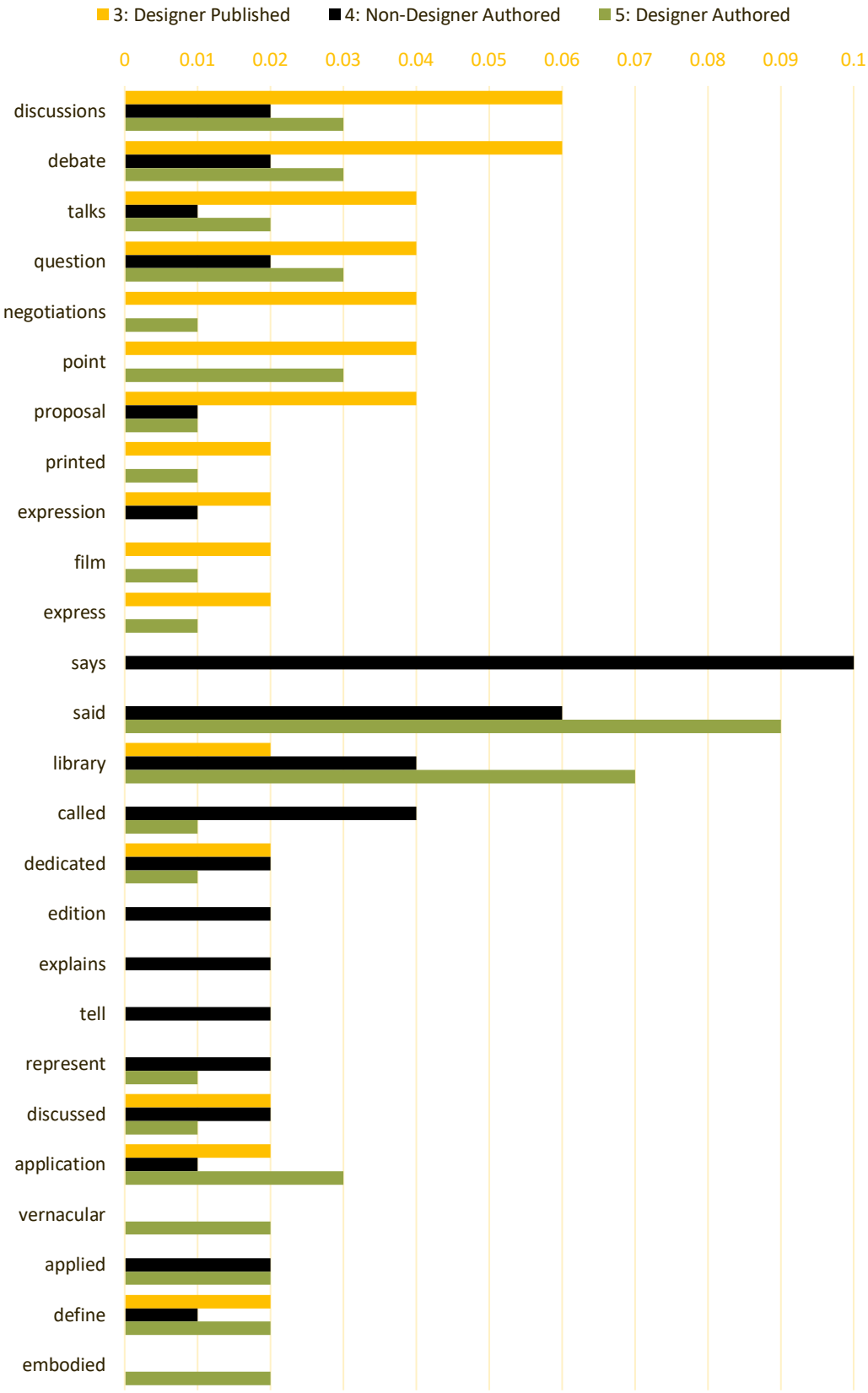


Figure 65
Social Actions, States and Processes Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency

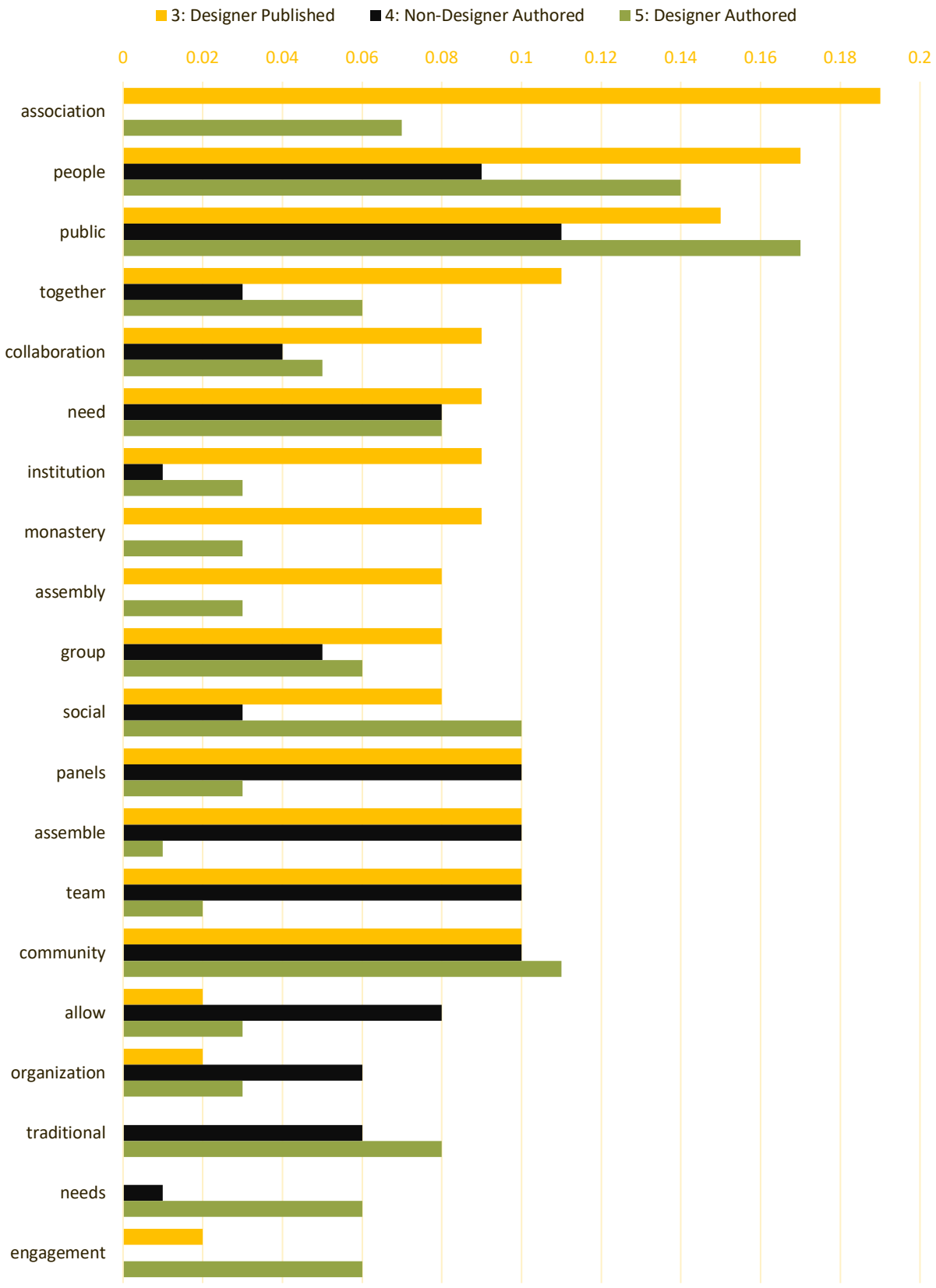
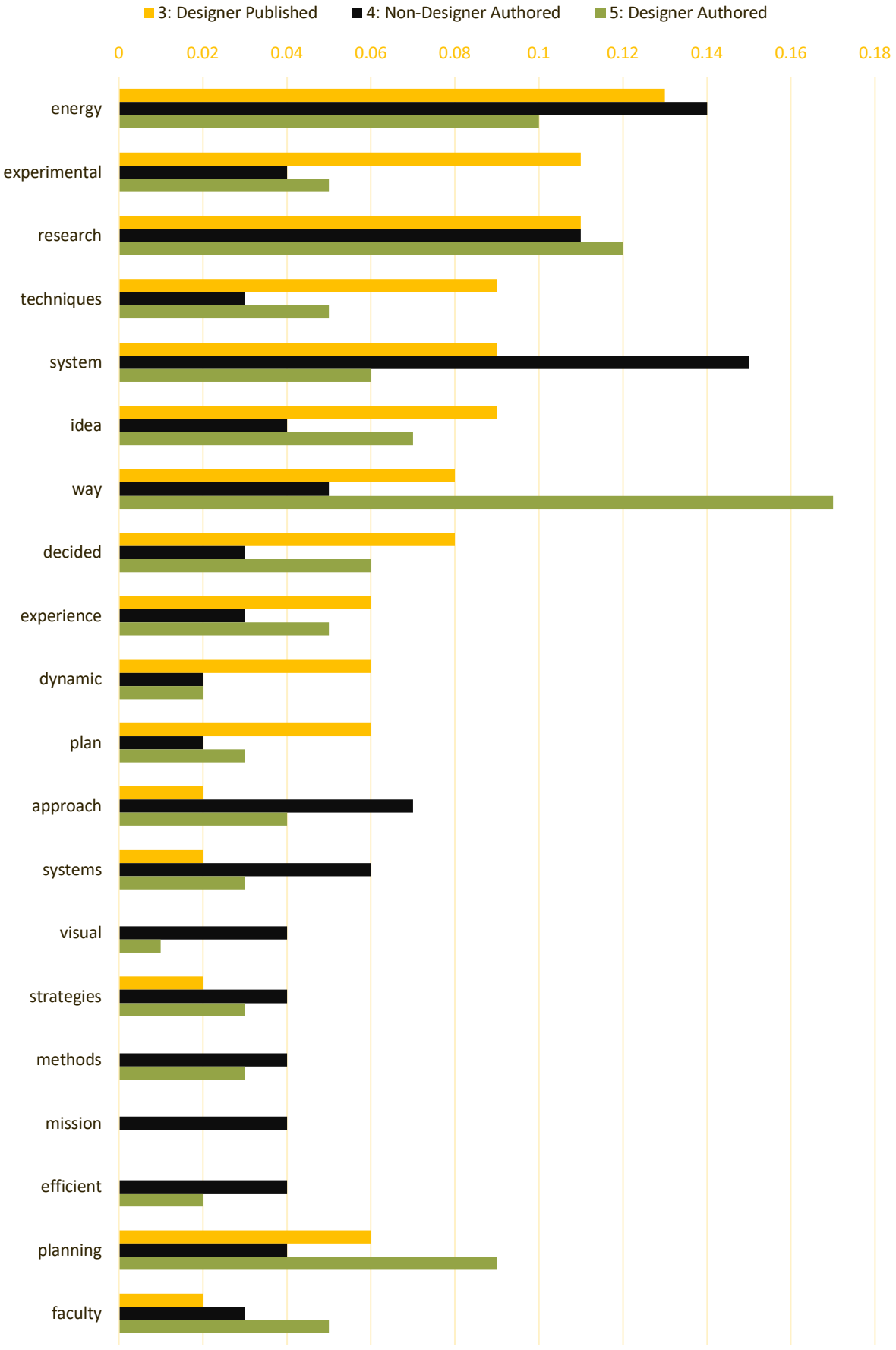
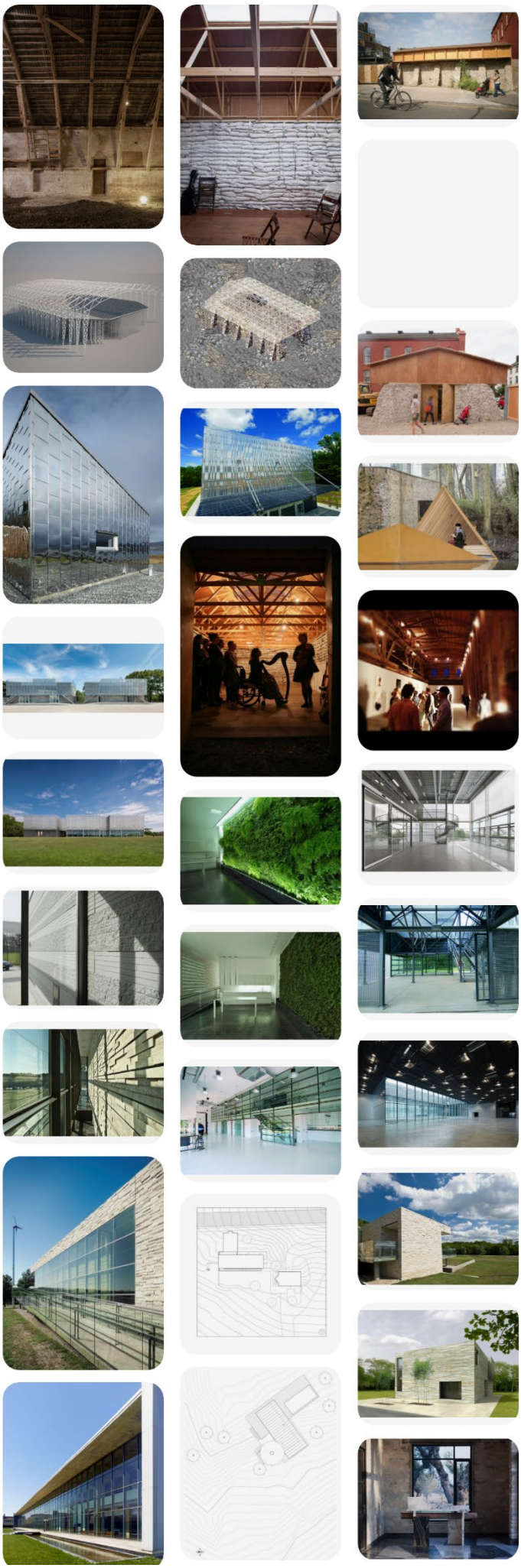


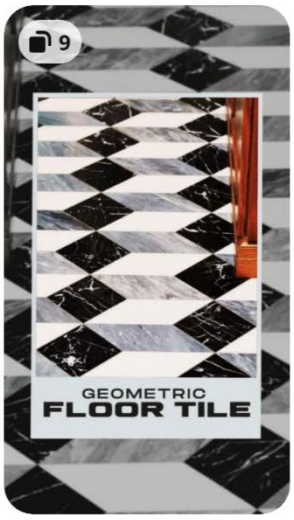
Figure 66
Psychological Actions, States and Processes Semantic Category. Top 10 in corpora 3,4,5 by Relative Frequency



Appendix 8: 99 Case Study Images and Corresponding Similar Images

Case study images sourced from references listed in Appendix 1. For individual photo references including for non-case study projects, please visit www.pinterest.com.au/rock3867/rematerial-projects-v-architectural-zeitgeist/

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GEOMETRIC
FLOOR TILE