Embedding Sustainable Design in a Design-Build-Studio:
An experimental bioregional community-based project

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ABSTRACT: Design guides for sustainable design typically concentrate on incremental improvement on current and past design practice; such as creating energy and water efficient buildings rather than buildings that have net positive ecological and social impacts. Often, environmental assessment tools are used for design, which are neither designed as design guides, nor do the custodians of these tools encourage their use as design guides.
In the creation of a Design-Build-Studio for third year students an approach to embedding sustainable design was adopted. As the project – a flood-response community project – evolved it became evident a new approach to sustainable design needed to be embraced. The principle of Positive Development as outlined by Birkeland[2] was embraced and embedded in the design-build process.
As with sculpture, where the output is the art object, construction was considered as an extension of the creative process; integral to the art and science of designing and erecting a built environment. This philosophy proved invaluable to the inexperienced labour-force when responding to the significant percentage of reused/recycled/donated/scavenged materials, whilst retaining the design intent. Limited resources and sustainable design motivated an emphasis on dematerialisation, heightening the relationship between design and connection detail. The outcome for this multi-award-winning (including a National Architecture Award), trans-disciplinary project spanning education, industry and community, successfully embedded sustainable design in a socially-responsible building contributing to bioregional growth.
Keywords: Sustainable Design; Design Build Studio; Education; Reuse materials; Community

INTRODUCTION

This paper explores an alternative to the traditional design and design-build-studio processes in pursuit of embedding sustainable design in practice. Investigations led to the implementation of eco-services design[2] (including Permaculture Design[6]) in a Design-Build-Studio. The underlying concepts of front-loaded design being able to solve issues of sustainability through Positive Development was tested and whilst the principles were found to be substantially true, there was also a significant proportion of back-loaded design when building with reuse/recycled materials. This led to a raised awareness of using recycled materials in new and eco-retrofit projects, and in addition to the practical impediments and costs[2]; the result being an evolution of the Positive Development paradigm shift.

For the purposes of this paper the definition of front-loaded design is the full resolution of design prior to a project's commencement on site, and back-loaded design is the necessity for design resolution during the construction stage.

CURRENT PARADIGM OF TRADITIONAL DESIGN STUDIO

Problem based learning is the backbone of traditional design-based studios and may seem on the surface to be front-loaded but in reality there is often little or no loading. Projects typically are conjectural, and whilst there may be significant time expended in the design process, there is often little resolution of the design to a stage where a project could be built[9], as indicated in Table 1.

Design Studio is often project/theme driven, exploring various design theories through the process. Sustainable design is often addressed as one of the themes/theories[10], unless the studio is designated a 'sustainable design' studio, projects may or may not address issues of sustainability.

Analysis is predominantly theoretical, virtual and surreal; and design can be self-indulgent, egotistical and narcissistic, rarely addressing the wider issues[11]. It is clear that the traditional design studio mode of teaching provides only some of the learning required by students of architecture.

TRADITIONAL DESIGN-BUILD STUDIO

Design-Build-Studios provide in many aspects of the traditional architect's apprenticeship, allowing students to fabricate and assemble conceptual ideas through the process of making, either individually or as a team[8]; or design, document and construct a building through a typical practice process.

Many of the Design-Build-Studios coordinated through architectural schools around the world are programmed over a number of years, and delivered by a new student cohort each Semester (or Term); or they are small and/or simple projects that can be delivered by one cohort. The former limits students' holistic experience of delivering a project and could alleviate the responsibility and learning opportunity of construction documentation; the later limits the range of learning experiences associated with larger projects.

Of the 25 design-build-studios reviewed the majority prefabricated their design-build projects. Whilst informative of innovative construction methods it portrays only a fraction of actual construction practices (construction administration) an architect is engaged in.

Table 1: Comparison of typical traditional design studio project with a typical traditional design-build studio project.

TYPICAL TRADITIONAL DESIGN STUDIO	TYPICAL TRADITIONAL DESIGN-BUILD STUDIO (PRACTICE)
Hand-out of fixed brief, preparation of brief by course co-ordinator	Hand-out of fixed brief, preparation of brief by course co-ordinator (possible evolution layout thro' community feedback)
Architect cohort only, no design team collaboration	Architect cohort and possible consultants
Real or notional (sometimes perfect) site	Real or notional site depending on nature of project
Ideal client, no committee /community engagement, no conflict	Real (possibly multiple) client, Possible committee/ community involvement, if community project
Limitless budget/ resources	Possible Budget limitations, Unknown to a large extent, topped-up by education funds and sponsors.
Sketch design reviewed by tutor/academic panel	Sketch design reviewed by academic panel, possibly committee/ client
Approach – accumulation and ordering of general information. Investigation of form follows function, user specifics, relationship diagrams, measurable / assessable criteria	Approach - accumulation and ordering of general information, information specifically related to problem in hand. Investigation of nature of problem.
Lack of (but if literal) code/ legislative requirements.	Minimum code/ legislative requirements dictate design outcome.
Final design – reviewed by academic panel in view to meeting AACA guidelines – complete design, possibly early design development stage.	Final design – reviewed by academic panel in view to meeting AACA guidelines, and possibly committee/ client. Developed design, limited construction documentation, possible bill of quantities
	Source materials
	Construction (majority off-site in order to reduce operations on-site)
	Completion, Hand-over

EMBEDDING SUSTAINABLE DESIGN IN DESIGN STUDIO

Sustainable Design in Studio education is often limited to architectural science and the application of climate responsive/passive design and sustainable design principles based on incremental improvements on traditional design methods. Traditional Design is often limited to focusing on measurable outcomes – such as outcomes assessed by assessment tools - but it is the un-measurable outcomes often value more – compounding positive footprints, sentiment, futuring, to name a few.

Traditional architectural design has been described as "our standard reductionist way of thinking" indicating the back-loaded design, "infected by outdated politico-economic constructs", employed in practice and studio produces obsolete built environments. Janis Birkeland's Positive Development[2] looks to design for pre-settlement conditions, focusing on the desired significant outcome, 'leap-frogging' legislation so as to comply but not be limited/dictated by, a design that is not only truly sustainably neutral but one that has a positive impact on itself and surrounds. This approach employs a paradigm shift to eco-services design[2].

When applied to Design Studios of collaborating design and architecture students at Queensland University of Technology and Griffith University the approach was to establish a baseline or foundation in sustainable design through research in sustainable design principles, followed by discussion of the various theories and processes, objective and critical evaluation of what was included and excluded; all before commencing Design Studio project, as indicated in Table 2.

Table 2: Comparison of typical traditional design-build studio project with a sustainable design-build studio project.

TYPICAL TRADITIONAL DESIGN-BUILD STUDIO (PRACTICE)	SUSTAINABLE DESIGN-BUILD STUDIO (PRACTICE)
	Set baseline/foundation: Sustainable design research and sharing / discussion by all involved
Hand-out of fixed brief, preparation of brief by course co-ordinator (possible evolution layout thro' community feedback)	Development of living brief and feasibility study in collaboration with client, through regular client meetings, and community engagement. On-going evaluation and implementation of eco-services design, and on-going exploration of design thro' various discipline lead charrettes
Architect cohort and possible consultants	Collaborative Design Team including In-house (architecture, landscape architecture, interior and industrial design students), client, Emergency Architects Australia, structural and hydraulic engineers; local Planning, Building and Plumbing authority; Local Flood Recovery representative; and builder
Real or notional site depending on nature of project	Real site (EPA sensitive – proximity to natural water way, riparian boundary, flood impact assessable, unstable soil conditions, research of organic farming/food production, permaculture zoning)
Real (possibly multiple) client, Possible committee/ community involvement, if community project	Real client, real community, real local authority engagement
Possible Budget limitations, Unknown to a large extent, topped-up by education funds and sponsors.	Fixed budget, limited to overall costs including supervising contractor, materials, sub-contractors, and all miscellaneous costs. Fixed education funds for student site accommodation only.
	Client/Architect and Client/Builder agreements, numerous insurances, risk assessment, risk management and construction site management reports
Sketch design reviewed by academic panel, possibly committee/ client	Living sketch design presentation and evaluation reviewed by client
Approach - accumulation and ordering of general information, information specifically related to problem in hand. Investigation of nature of problem.	Approach - accumulation and ordering of general information, information specifically related to problem in hand, form follows climate, socially/bio-regionally/ climate/ locality responsive, value of un-measurables. Investigation of nature of problem, develop and refine solutions.
	Communication and coordination of design solution with Design Team
Minimum code/ legislative requirements dictate design outcome.	Interpretation of intent of code/ legislative requirements integrated in design outcome.
Final design – reviewed by academic panel in view to meeting AACA guidelines, and possibly committee/ client. Developed design, limited construction documentation, possible bill of quantities	Final design – reviewed by client, academic panel in view to meeting AACA guidelines, and builder. Developed design, construction documentation, bill of quantities, schedule of materials, tools and equipment required. Integrated innovative technologies.
Source materials	Source materials (competitive pricing/bidding) prior (5%) and predominantly during construction due to fast-track program
Construction (majority off-site in order to reduce operations on-site)	Off-site Construction (incl. establish site and volunteer accommodation, safe site procedures, material store, waste processing, tool and equipment store, break-out space, amenities. Administration of construction
	Careful assessment & processing of reuse/recycle materials, construction innovation and refinement of connection detailing, dematerialisation,
Completion and Hand-over	Completion, certification and Hand-over
	Feedback

The principle of Positive Development as outlined by Birkeland[2] was embraced and embedded in the design-build process. This empowered students to front load the design process and 'loop' sustainability issues and design evolution into a typically linear process. Boulanger and Brechet[1] describe the five most important criteria that should be considered for modelling sustainability issues, specifically:

(1) an interdisciplinary approach;
(2) managing uncertainty;
(3) long-range or intergenerational point of view;
(4) applying a global-local perspective; and
(5) stakeholder participation.

Empowering the design students with the values of eco-services designs created openings in design through sustainable-design-based thinking.

DESIGN-BUILD STUDIO PROJECT

The design build project in this paper is the response to flood damage which occurred during an extreme weather event in the Lockyer Valley (Queensland, Australia) on the 10th January 2011 when 160mm of rain fell in a 2-hour period on already saturated catchments. An 8m tidal wave of floodwater and debris descended on the Valley's towns and countryside[7]. 5,000 people fled their homes, 500 were airlifted to safety, over 120 homes were destroyed, 855 vehicles displaced, 80% of Council roads damaged, 50 families were left with nothing and more than 20 lives were lost in the region.

As a result of the flood the Murphy's Creek Campsite facilities of the BNT were destroyed and the trail closed. The campsite facilities, including an animal shelter, hitching rail, feed room, tack/store room, first-aid room and amenities; are used by trail-riders who follow the historic pioneer/stock routes, that run the length of Australia's east coast. The Trail is the longest marked, non-motorised, self-reliant multi-use trekking route in the world, stretching 5,330 kilometers from tropical North Queensland to Victoria. The trail and its facilities make a significant contribution to the regional and cultural diversity of the area and is thus considered a bioregional resource[1]. After the community's losses it was necessary to rebuild. The Client/Owner of the land on which the campsite sat donated funds to erect a basic metal agricultural shed. It was these funds that formed the budget and opportunity for the Studio's project.

Real Studio, the Design-Build-Studio, saw 3rd-year architecture, landscape architecture, interior design and industrial design students design and build a rural agricultural shed for use by the BNT at Murphy's Creek. (Refer Fig. 1 proposed design). At its base, the building is about providing maximum comfort to weary travellers, simultaneous to the regular agricultural functions on alternate occasions for the operation of a sustainable and organic food producing farm.

Figure 1. Perspective view showing original design intent

The aim of the project was to teach collaborative design students the social responsibilities of their discipline while providing an issue-orientated, sustainable, well-constructed and inspirational built environment for a community. The Studio's vision - to work on 'projects that benefit a wider community'- matched the requirements of the challenge of rebuilding the Murphy's Creek Campsite facilities.

It was essential the architecture respond to its location. The rural context of the site lent itself to sustainability and the ideologies of rejuvenation after the 2011 Floods. The building was designed to maximise the site's specific natural environment, a registered area of significant habitat, and for this reason the design not only replaced the existing facilities but is sensitive to enhancing the high biodiversity of the region.

The effects of flood water varied, in the Murphys Creek region, upstream, the water ran through' in a matter of hours; compared to regions downstream such as Goodna and Ipswich, where water took days to run through. Buildings with a higher survival rate in the Lockyer Valley (where the velocity of the water was greatest) allowed water to run through' them, were structural grounded and weighted by their material composition. In the unlikely event such a flood should reoccur the building was intentionally designed to be flooded. The layout of the shed allows flood waters to run through it thus creating less pressure points and structural damage. Materials are durable and the majority of the building is single skin so it can be easily cleaned out post-flood. The wet-room and First Aid room cavity wall lining materials - of structural plywood and acrylic cladding - are proven to function better in water compared to traditional construction cavity construction; and are screw fixed so they can be removed and replaced when cleaning cavities.

Where possible the Trail was designed as a "living history of our country", and this philosophy was mirrored in the building's redesign retaining elements of the previous structure. The height of the retrieved river

stone walls that wrap the building serve as a record of the height and power of the flood water (identified as 271.808m AHD), and many of the materials used in the structure were sourced from the site and the local region.

THE ART OF POSITIVE MAKING

A significant percentage of the DBS construction materials were reused/recycled/down-cycled/scavenged.

Table 4: Material Life Cyle.

Element	Reuse	Up-cycle	recycle	down-cycle	New-Seconds/Damaged	New-donated	New-purchased
Piers						100%	
Slab						100%	
Paved floor						100%	
Columns/Structure	100%						
Steel beams			100%				
Timber framing	10%		40%			20%	30%
Timber cladding			100%				
Concrete blocks			70%			30%	
Bricks					100%		
Rocks		100%					
Roof cladding				20%		80%	
Doors	35%			65%			
Windows			65%	35%			
Timber lining			65%				35%
Acrylic lining			100%				
Sanitary fittings							100%
Electrical fixtures						5%	95%
Hydraulic fixtures						50%	50%

The impact of using such a high percentage of reused/recycled materials, as shown in Table. 4, sourced during construction lengthened the design process resulting in an extension of Positive Development's front-loaded design (employment of eco-services design), to front and back load design (employment of reuse/recycle materials).

Through the employment of reusable/recyclable materials the studio process using an interactive, imaginative design dominant mode, facilitated not only the creation and implementation of a sustainable design but design in its execution. As an artist - where the output is the art object – the construction became an extension of the creative process; and integral to the education of the art and science of designing and erecting a built environment. The architect and the builder were required to work as a team. This proved invaluable when responding to recycled materials and an inexperienced labour-force, whilst remaining true to the design.

Materials obtained/confirmed prior to commencement of work onsite included: 6m^3 concrete, flexi foam pod system, slab reinforcing steel and mesh, remains of the flood damaged and dismantled shed, and other local flood 'debris' available for up-cycling. As a result of the fast-track construction program the majority of materials were sourced immediately prior and during construction; of which significant percentages were sourced locally, as indicated in Table 3.

Table 3: Source of Materials

Element	Site sourced	within 25km	within 50km	within 100km	within 125km	within 150km	within 175km
Piers		90%					10%
Slab		90%				10%	
Paved floor		100%					
Columns/Structure	5%	95%					
Steel beams		100%					
Timber framing	10%	90%					
Timber cladding					100%		
Concrete blocks		100%					
Bricks						100%	
Rocks	100%						
Roof cladding		20%				80%	
Doors	35%	65%					
Windows	65%	35%					
Timber lining					100%		
Acrylic lining		100%					
Sanitary fittings					100%		
Electrical fixtures		95%			5%		
Hydraulic fixtures			50%		50%		

Dematerialisation whilst evident in some traditional design-build-studios may not be purposed. In a sustainable DBS the multiple-purpose of each material and reduction in single purpose materials (e.g. non-performance) proved a useful method of reducing material quantities. Limited resources and sustainable design motivated an emphasis on dematerialisation, thus heightening the relationship between design and connection detail. This too had a time impact on design.

Figure 2. Work in progress showing the structural frame and masonry cladding at lower levels

The art of making raised awareness of the implications of reusing/recycling materials. The increased time/labour, wear on tools and processing of up-cycling materials adds to perceived cost of using such materials. However this negative perception does not take into account the actual sustainability cost. Birkeland[2] does not discuss these implications in detail, whilst acknowledging practical impediments, costs and deconstruction. It was evident in the DBS the impact of reuse/recycle materials on design (Figure 1 of proposed design and Figure 3 of final build).

Figure 3. The finished building showing deviations from the original design through material-induced design changes

CONCLUSION

Traditional design-build-studios have advantages over traditional architecture studios in that they allow students the opportunity to work in a collaborative environment to develop additional skills and realise a real building. Design-build-studios often attract individuals with a desire to contribute to a greater need and experience, greater than their own; and by nature elements of design-build-studios are sustainable, if primarily from an economic and/or environmental perspective. But there is little record of the design process focusing on eco-services design. This paper has shown how sustainable design has been successfully embedded in a design build studio to create a building that is of significance in the community.

Significant challenges exist when working with second-hand and new donated materials, which require further design input and frequent detailing changes. As with sculpture, where the output is the art object, the construction process was considered as an extension of the creative process; integral to the art and science of designing and erecting a sustainable built environment. The limitations of labour and material resources when combined with sustainable design principles motivated an emphasis on dematerialisation, heightening the relationship between design and connection detail.

The outcome for this trans-disciplinary project spanning education, industry and community, successfully embedded sustainable design in a socially-responsible building that makes a significant contribution to bioregional growth.

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