The aesthetics of environmental performance - a pedagogical approach to architectural design

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ABSTRACT:

This paper reflects on the experiences and outcomes of a recent design studio led by the Author in association with Dominik Holzer (SIAL, RMIT and Arup) at the University of Technology, Sydney. The studio employed building environmental performance as a critical driver in the morphogenetic development of design, and extended the use of digital media beyond generative processes merely for their formal outcomes. It also incorporated an investigative workshop in bionics led by Michael Hensel and Defne Sunguroglu (Ocean North) to investigate Australian native plants in relation to their natural habitat and performative capacity embedded in their morphology and physiology with the aim of deriving design principles for architecture. The paper reflects on the studio outcomes and feedback in the light of the operational issues of the studio including prior knowledge, staffing and expertise, facilities, timetabling, assessment structure including group and individual work. The paper highlights the benefits and challenges of the thematic studio that by its nature is required to straddle objectives across the specific sub discipline of environmental studies as well as the broader ambitions of creative processes towards architectural design. The adopted approach, which redirects attention to the design process and outcome, is in contrast to a more traditional view of the architectural studio project as the end in itself. The positive outcomes and student feedback indicate that that it is possible to bridge the perceived disconnect between architectural design and science/technology, and develop a designerly way of approaching environmental performance through experiential learning in the design studio

Conference theme: Education. Science supports instruction and pedagogy; it assists in improving approaches to teaching and learning.

Keywords: environmental performance, pedagogy, architectural design, bionics, digital tools

1 BACKGROUND

In response to concerns of climate change, the growing emphasis on sustainable architecture is matched by a plethora of codes and rating schemes that seek to mandate or benchmark building environmental performance in many parts of the globe. In Australia, the Education and Sustainability Policies of the Australian Institute of Architects and accreditation processes of the Architects Accreditation Council of Australia (AACA) commit to implementing sustainable design practices across all its endeavours and reinforce the importance of environmental studies and architectural science in professional architectural education.

While the value of studio teaching approaches as a means for encouraging reflection and deeper learning is well documented (see for example Schon 1985, Green & Bonollo 2003), a review of several papers on the pedagogical approaches and outcomes in the discipline of environmental studies reveal consistent themes surrounding the compartmentalised approach to teaching these subjects in architectural courses, the desire to integrate environmental studies into studio teaching, and the need to make the discipline area more appealing to students (for example see AIA, 2006, Rutherford 2006 and Loftness, 2005). Environmental aspects have traditionally been taught as separate subjects from architectural design in most schools of architecture. Although some examples exist both locally and overseas where integrated environmental science and technology courses operate in a "servant mode" to extend the resolution of the concurrent or previous design project, there is limited evidence of an alternate approach to architectural design studio teaching where the objectives of the discipline are primary drivers within the studio. This paper focuses on an architectural design studio titled Environmental Performance that was offered for the first time in Autumn 2008 as part of the new professional Master of Architecture (MArch) program, at the School of Architecture, University of Technology, Sydney. This paper will seek to highlight inherent opportunities and challenges of the “thematic studio” that by its nature is required to straddle objectives across the specific sub discipline of environmental studies as well as the broader ambitions of creative processes towards architectural design. The adopted approach redirected attention to the design process and outcome and is in contrast to a more traditional view of the architectural studio project as the end in itself. A brief description of the studio, is followed by a detailed reflection on studio processes and outcomes to distil lessons and implications for improved instruction and pedagogy.

By way of background, the new Masters at UTS is envisaged as an “innovative and flexible professional degree. Through a non-sequential structure, which allows students to select from a range of core and elective subjects, it gives students choice regarding their professional specialisation that will best serve them in their future careers” (UTS, 2008). The
MArch builds upon the foundations laid in four vertical streams - Architectural Design, Technology and Environmental Studies, History and Theory and Communications in the Bachelor of Arts in Architecture (BA) course. In the BA, the building blocks of environmental studies and architecture science are developed in an introductory subject Architectural Environments and Culture and three detailed subjects Thermal Design and Environmental Control, Lighting Acoustics and Advanced Environmental Control and Built Praxis (applied services). Subject delivery is achieved through lectures, tutorials and computer labs and a culminating assessment task requiring “design synthesis” which is supported with studio based tutorials. Under the newly adopted Masters structure students are required to complete four studios from a selection of 13 that are offered each year over their two years of study. With a good coverage of architectural science and environmental studies and its links into concurrent design projects in the first three years of architectural study, it could easily be argued that the fundamentals are “done and dusted” and students will automatically integrate what they have learnt in their designs regardless of their choice of design studio in their final years. However, at UTS, a strong emphasis on modes of practising in architectural design, and an ambition to produce graduates who are able to apply ethical, environmental, cultural, aesthetic and technological considerations in architectural practice (UTS, 2008) is continued by offering two complementary studios namely Environmental Performance and Environmental Sustainability.

The Environmental Sustainability studio is concerned with the broader issues of sustainability at the scale of the city and major architectural interventions, whereas the framework for the Environmental Performance studio allows for exploration at the level of design process and decision making, including the use of computational and other tools to generate and assess architectural interventions for their performative capacity. Each studio comprises 12 credit points, or half the loading of a full time semester. Under the course changes, the remit for all studios is go beyond fulfilment of a pre-set brief. The studios seek to enhance a critical understanding of architecture as both a discipline with an existing body of knowledge and a set of practices that continuously challenge and add to that body of knowledge. Research is undertaken as a precursor to decision-making, during design and in reflection on design development.

2 COURSE STRUCTURE AND METHODOLOGY

The studio sought to address the aesthetics of performance and alternate approaches for architectural design in response to global warming and climate change. Building Information Modelling (BIM) processes are well documented for their capacity to support effective design collaboration towards optimal building performance while using a shared building model in a collaborative design setting (For example see Plume and Mitchell, 2007). However, in most academic environments of professional architecture courses, the true interdisciplinarity (with input from mechanical, structural and construction engineering) that is required to drive the highly specialised software is missing. Coupled with the reality of the extent of detailed information needed for the various analyses, and the effort of gaining seamless transfer (interoperability) from one software platform to the other, in most situations, this means the benefits of BIM only come into play once a design concept is locked in, allowing for design decisions to be post rationalised or optimised using various performance software results.

In contrast, a key focus of the Environmental Performance studio was the use of building environmental performance as a critical driver in the morphogenetic development of design while extending the use of digital media beyond generative processes merely for their formal outcomes. Our focus was on methods to gain useful feedback in the early design-stages, where one was not too precious about design concept and there was the willingness to develop and generate a number of design possibilities. In this context, the iterative process of performative analysis and design development emphasised the shift from form making for purely aesthetic considerations to outcomes evolved through form finding (after Laiserin, 2008). To aid performative analysis, the studio included the use of ECOTECT®, an environmental analysis tool where the main advantage is its focus on feedback at the earliest stages of the building design process and its modelling and analysis capabilities to handle geometry of any size and complexity (Crawley 2008). We also used Evolve 97 which enables evolutionary structural optimization (ESO) of a deliberately oversized structure, through removal of elements under least stress to evolve towards highly optimized shape (Holzer at al., 2007). Simultaneously, the studio sought to recognise the multi dimensional and trans-disciplinary nature of sustainable design. A critical inclusion from this standpoint was an investigation into bionics – a study of natural systems with the aim to derive design principles, and implications for architecture. A brief outline of studio activities together with selected examples of student projects is provided below. The projects depict the range of analytical and modelling approaches pursued and studio outcomes, however a detailed presentation of the performance analysis of projects is outside the scope of this paper.

Figure 1 An example of the canopy exercise.
Design development included of physical modelling and testing, and evolutionary structural optimisation towards design development [Frankie Layson, Ali Naddi, Phillip Meehan] The brief required development of a canopy that could achieve 100% shading to a building facade and 3m deep patio oriented north west during a stipulated time (2pm-5pm during summer solstice) and generating the structural support system using feedback from evolutionary structural optimisation (ESO) whilst maintaining views, minimising canopy area and material and allowing unobstructed movement under the canopy.
The studio was structured into three phases, and departed from the traditional mode of studio operation of 6 hours per week on a weekly basis. In addition to a weeklong intensive Investigative Workshop over the mid semester break, the group met for 9 hours every alternate week, or 6 sessions over the semester, with the final crits in the final week of the teaching semester. The studio was carefully designed to ensure alignment between course objectives, content, learning activities and assessment in order to ensure deep learning approaches in students (Ramsden, 1992). The initial Design Process phase (conducted over three biweekly sessions) was designed to get students to rethink their design methodology in the light of multi-objective criteria while developing their analytical, computational and modelling skills. Figure 1 and Figure 2 show aspects of the morphological design development and performative design analysis from the Canopy exercise in the light of multi-objective criteria for solar shading and evolutionary structural optimisation.

Figure 2 Another example of the canopy exercise. [Rebekah Clayton, Hugh Irving, Benjamin Wollen]

Shown here are some of the iterations of environmental performance analysis morphogentic development and material optimisation from sunshading studies, digital and physical modelling and evolutionary structural optimisation

The second of these exercises - the Parametric Screen project required exploration of parametric principles of associative geometry, and controlled repetition and variation of constituent elements to satisfy criteria for environmental performance for daylighting and thermal performance.

Figure 3 Two examples of the screen exercise using daylight, solar access and solar insolation analysis in conjunction with parametric modelling [Top Row: Jeremy Unger and Pietro Abdo; Bottom Row: Frankie Layson, Ali Naddi, Phillip Meehan]

The project called for the development of an external, screen-like element wrapped around a nondescript "glass box" office buildings to create a feature of interest that could control solar gain, allow for improved daylight distribution to the office plate, reduce the solar loads on the façade yet admit sunshine to lounge areas in winter. For all students this was their first introduction to the parametric capabilities of Generative Components® and Explicit History® plugin in RHINO®.

The Design Process phase was followed by an Investigative Workshop led by Michael Hensel and Defne Sunguroglu from Ocean North, in association with the two studio leaders. The group was assisted in their botanical studies by Paul Greenfield of CSIRO and Chase Alive. With the emphasis on bionics, students studied selected Australian native plants in relation to their natural habitat and their performative capacity embedded in their morphology and physiology with the aim to derive design principles for architecture. The field work conducted at the Basin area of Ku-ring-gai National Park, focussed on mapping, which was seen as a useful way of documenting and analysing the two way feedback between the selected plant and its environment, and thereby understanding its performative capacity. Over a two day period, students
studied their selected plant and its detailed relationship to its immediate surrounding by mapping a 5 x 5 m quadrant encompassing it. In addition to documenting physical characteristics such as terrain and soil condition, students logged measurements of temperature, humidity, daylight intensity, wind speed and direction over time, and also gained a wider understanding of surrounding area. Additional information on the macro scale was sourced from topographical maps and concurrent Bureau of Meteorology data. In the computational workshop that followed, groups developed a series of spatial and temporal maps ranging from the micro through to macro scale and digital models of relevant plant morphology with accompanying performative analysis and literature study which together served to explicate the context specificity and feedback between the organism and its environment. Students were also required to reflect on implications for architectural design and the scales at which performative principles and criteria might be applied.

Figure 4: An example of some the plant morphology studies at macro, meso and micro levels [Chanel Carr, Kevin Bradley and Luke Novotny]

The final stage, Design Synthesis staged over the last 3 biweekly sessions, pulled together the various threads of the studio that had been explored to date through a design project for a small scale ‘off the grid’ ecological research station. The brief was kept simple with a requirement for glare free light and minimum discomfort due to overheating and overcooling with an aspirational target of achieving 18 – 28 °C for 95% of the year. Aside from building performance, the project sought inclusion of at least one “broader” and often regenerative environmental criterion such as rainwater harvesting and storage, fire resistance and material sensitivity (embodied energy, recycling reuse and upcycling). Students were assessed for their design process as well as architectural project exposition and presentation. Significantly, the project required students to consider what design and environmental performance principles could be gleaned from their plant morphology studies for transference to the built artefact while instigating a morphological development of the project in response to the performative criteria. Although it would have been interesting to explore transference of principles in an alternate urban site, it was decided that the hypothetical project continue at the Basin in order to maximise the benefit of the rich data collection, site analysis and mapping developed during the workshop. Some of the outcomes and their approaches are shown in Figure 5 and Figure 6. The quality of outcomes and other implications are discussed below.

Figure 5: Design development for an ecological research station [Luke Novotny]

The project was developed primarily from a context specific response to environmental and site issues, and included wind studies to modulate form and surface, as well daylight and thermal analysis and a in depth structural and materials strategy investigated through physical and digital modelling.
Figure 6: Design development for an ecological research station [Christopher Kelly].

The project was influenced by performative analysis of the casuarina, venturi effect and constriction velocity that triggers seed dispersal, and precedents in architecture to investigate use of prevailing winds for power generation. Simultaneously, the project used daylight and thermal analysis to reconcile the form and employed parametric principles to generate the louver system.

3 INNOVATION, INSPIRATION AND INSTRUCTION – REFLECTION ON STUDIO PROCESS AND OUTCOMES

Student Feedback

The subject rated very well with over 78% selecting Agree or Strongly Agree, and close to 90% selecting Neutral or above for all categories other than resources. A summary is provided in Table 1. The average score for overall quality was 3.74. Rather than mount an argument that the subject would have averaged at above 4.00 (equivalent to Agree) without the three respondents (11%) who were the only ones to choose Disagree or Strongly Disagree on any of the 11 questions, it is more relevant to ascertain the sources of dissatisfaction. Interestingly, two of these respondents returned positive comments about the approach being "very interesting", but recorded dissatisfaction at the bi-weekly contact for the studio. The primary suggestion for improvement raised through open-ended comments across respondents was the need to improve access to software and computer labs as reflected in a mean score of 3.5 for resources.

Comments about the positive aspects of the course included: "A new way to approach design. The camping trip was a positive" and "The new studios with the masters, allowed for much greater thought provoking environment. This subject is great in that it pushes the use of cutting edge research and technique". A respondent who rated overall quality as 5.0 commented "I enjoyed the intensity and amount of work that had to be produced and the methods by which the work was produced". The same student also noted "I struggled with putting my designs on computer mainly because of a limited knowledge of 3D modelling packages. This year was the first time I was introduced to RHINO. An improvement would be a long term one where the school introduces this to student(s) much earlier". The positive feedback of the subject being thought provoking and interesting, is noteworthy, particularly given aforementioned concerns of a perceived lack of interest in this discipline area and the value of such experiences in developing deep learning approaches. Other aspects of student feedback is discussed in subsequent sections.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Mean(sd)</th>
<th>% 4.0 and above</th>
<th>Criteria</th>
<th>Mean(sd)</th>
<th>% 4.0 and above</th>
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<tbody>
<tr>
<td>Subject delivery consistent with objectives</td>
<td>3.81 (0.74)</td>
<td>89%</td>
<td>Teacher - well prepared</td>
<td>3.93 (0.78)</td>
<td>85%</td>
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<tr>
<td>Subject thought provoking</td>
<td>4.04 (0.71)</td>
<td>85%</td>
<td>Teacher - able to explain concepts clearly</td>
<td>3.93 (0.68)</td>
<td>82%</td>
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<tr>
<td>Assessment fair and reasonable</td>
<td>3.85 (0.66)</td>
<td>85%</td>
<td>Teaching of staff</td>
<td>4.00 (0.78)</td>
<td>89%</td>
</tr>
<tr>
<td>Appropriate resources for subject</td>
<td>3.50 (0.81)</td>
<td>54%</td>
<td>Tutorials assisted learning</td>
<td>3.81 (0.96)</td>
<td>78%</td>
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<tr>
<td>Constructive feedback received</td>
<td>4.00 (0.68)</td>
<td>86%</td>
<td>Teaching in tutorials</td>
<td>3.77 (0.91)</td>
<td>81%</td>
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<tr>
<td></td>
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<td></td>
<td>Overall satisfaction with quality of Subject</td>
<td>3.74 (0.90)</td>
<td>78%</td>
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N=29, n=27. Overall Response Rate = 93%
All variables are rated on a 5 point scale where 1=Strongly Disagree, 5 = Strongly Agree

Table 1: Student Feedback indicating percentage of respondents in each category rating Agree (4.0) or above

Building on prior knowledge and computational skills

The studio relied heavily on the prior learning in environmental and structural design that had been developed in the BA courses. This enabled time in the studio to be used effectively, without the need for content based lectures. Where further research was required, students were able to initiate this on their own, reinforcing the importance of the
foundational material taught in earlier years. There were no software prerequisites set for the course. While most had used ECOTECT® as part of the BA course, this was the first time they were using the tool outside the context of those subjects. Although advanced 3D modelling software such as RHINO® and 3ds Max® now form part of the routine suite of tools introduced to first year students at UTS, most students entering the subject this year only had basic CAD skills in ArchiCAD, SketchUp and AutoCAD®. About half the class undertook a 2-day introductory workshop in RHINO® offered separately at the start of the semester. Given this background, the authors were pleasantly surprised by manner in which most students rose to the challenges of learning to use the various computational tools. In the early phase of the studio where students were still developing computational skills, the assessment task called for an individual account and critical reflection on the computational and design development instead of assessing the end outputs at the group presentations in isolation. This move put the emphasis back on design development, evaluation and process rather than an expectation to simply show up with the best design outcome.

In addition to ECOTECT® and Evolve 97 to evaluate environmental and structural performance, a number of students used a Computational Fluid Dynamic software such as ViziFlow and RealFlow, to investigate design modulations in response to air movement in their final project. In the feedback received, students wished they had more time to experiment with the tools, while some requested easier access to computer labs and more training in advanced software such as Generative Components® and Explicit History Plug In for RHINO®. Further discussion of tools and modelling exercises used in the studio can be found in another paper (Holzer, 2008).

**Developing collaborative approaches - The benefits of group work and buzz of the intensive workshop**

To alleviate concerns surrounding software capabilities, students were set up in groups of 3 for two thirds of the semester. The value of effective learning interactions between students whether formal or informal is widely recognised (Biggs 1999). In this instance, working in groups enabled students to develop and contribute specialist skills within the team and more importantly benefit from teaching and learning from one another. Potential problems of a lack of ownership of group outputs were managed through carefully structured assessment tasks and by encouraging students to assume quasi-specialist roles within the group. The best aspects of group working and collaboration came to the fore as groups and larger conglomerations worked together to cater for food for all six meals while the class camped at the Basin, in the Ku Ring Gai National Park north of Sydney, where all supplies had to be ferried across to a site with no road access! For a class cohort that had previously not gone on any field trips, the social dimension was significant. The author observed that the experience also engendered a level of generosity whereby the students themselves took the initiative to share and post mutually useful material via the school server. This has the spin off of increasing the quality of the output across the board, but also ensured inclusion of students who might be typically more reticent on this front.

The camping trip and the intensive workshop generated a strong sense of achievement and enthusiasm and was the high point of the subject for many, to the extent that a period of inertia followed when the individual design project was introduced after the two week break. For the students, this was a point of opportunity and challenge to take individual ownership of their work, which they did. Nevertheless as the studio progressed through the third phase of the individual design project, many students continued to benefit from working collaboratively in locating new analysis tools and sharing insights on “how to” across the range of their computational endeavours, while retaining authorship of their design ideas. In the formal feedback received, one respondent commented that they were “Extremely pleased with the intensity of the studios. After returning from the Basin, the students were able to learn from a collaborative environment.”

**Inspiration from nature, and the aesthetics of environmental performance**

An important dimension of preparing students for working in trans-disciplinary contexts was the requirement for students to work and research beyond the traditional domain of architecture, and to engage in a discipline (namely botany and bionics) outside of their comfort zone. While by no means a detailed study in the discipline, feedback from the students was positive. “Some of the plant analysis felt quite strange at first, but very interesting and thought provoking”. An early challenge for students was the need to distill performative principles such as differential expansion of materials, modulation of surface area, self shading, fire resistance, wind modulation and water storage rather than simulate formal qualities or even functional analogies (after Aldersey-Williams, 2004) of their plant. Simultaneously they had to come to grips with the similarities and differences when moving from a plant to a building as the locus of investigation. The range of different design outcomes reflect the varied starting points from plant morphology, and different emphases students applied to the various performative criteria, where trade-offs occurred, how results were evaluated.

As outlined elsewhere (Holzer, 2008), those students who put a strong initial emphasis on exploring and mapping the imminent environmental and topographical conditions at their site to then relate them to the program appeared to struggle most in the beginning of the exercise, but managed to develop the richest proposals for the morphogenesis of their final project. On the other hand, it was noted that in a bid to satisfy environmental performance criteria, a sizeable number of students had neglected the finer architectural resolution of aspects of their design. Issues included unresolved aspects of entry and approach, and incongruence between the performative language of their designed artefacts and depicted design elements such as openings and furniture. Many students felt that the effective period of five weeks from project introduction to final presentation, with only two contact sessions during that period, was not adequate to take the projects to a level of desired resolution. On reflection, it is considered that a slightly longer lead time for the design synthesis task, and/or weekly studio sessions are needed to provide more frequent opportunity to emphasise successful approaches and discuss issues in emerging designs with students. Such an option would also afford students time to move on to a higher level of architectural resolution once they call a halt to their morphological development.

**The studio as the venue for synthesis - Implications for staffing, timetabling and resources**

An oft repeated concern is that even when integrated into design studio, building science and technology are perceived and conducted as an add-on project (see Wood, 2006). Austin (2007) argues that integration of design with technologies
“is too much to ask of any student during, or even after, five years of study” on grounds that the technologies are only half understood and there is a lack of a serious role for “technologists” in the design studio. With respect to the latter, it is our view that for any successful studio embracing environmental performance and sustainability, the expertise must be intrinsically located within the studio. It is also crucial that the studio objectives has buy in from all design tutors, and that the students see and know that it is being taken seriously at all levels - not only through explicit course objectives and assessment criteria but also in terms of how the issues are naturally part of the day to day concerns of the studio.

In this studio, the positive feedback for teaching quality, tutorials and constructive feedback (Table 1) was reinforced by open ended comments. Students also commented positively about the complementary role played by the two lead tutors. Both had architectural training and a strong interest in sustainability and design process, however one specialised in environmental performance, evaluation and user studies whereas the other had an architectural practice background with a specialist capabilities in digital design, parametric tools and evolutionary structural optimization. This was further augmented with insights into performative design and bionics from the Ocean team and specialist expertise gained from the botanist at the intensive workshop. The mode of team teaching had the benefits for the tutors as well, with productive exchange of ideas and an ability to offer a studio that went beyond the sum of their individual capacities.

It should be noted that thematic studios of this nature require substantial time for planning and coordination of external teaching staff and field trips. Additionally, there is a need for flexibility, both in terms of timetabling to accommodate intensive workshops and movement between studios and labs, as well as in responding to learning outcomes as they develop. In this instance, aspects of the final project were only finalised once the outcomes of the investigative workshop which highlighted the importance of context specificity was known.

The school is only into its second year of exclusive studio space for the School of Architecture, while computer labs with the dedicated software (130 seats for general access) are shared across the whole Faculty of Design Architecture and Building. Over the semester, many in the studio including those with their own laptops, relied strongly on these physical spaces for group working, with the wireless networking capability of the studios, access to software, and fast machines in the labs at university being key drivers. Although students were very appreciative of the additional resourcing via guest tutors, a number of students raised the issue of difficult access to computer labs outside the weekly class bookings, which is also reflected in the lower feedback for resources compared to all other categories in Table 1. As the studios and computer labs in most schools are increasingly occupied for teaching, schools will need to look at options for increasing labs as well as spaces for casual working with access to wireless networking and alternate modes of software licensing for student use on individual laptops to continue to cater for student access and group working.

Developing a designerly way of approaching environmental performance
Lawson (2004) observes that “designers work in the solution focus manner that depends heavily upon design gambits based upon recognizing design situations amenable to solving certain problem situations” (p105). He also contends that unless knowledge has been taught in a way that is designerly (after Cross, 1982) they will find it hard to “connect and use the theoretical knowledge when actually designing” (p 105) and notes “that design knowledge depends heavily upon precedent or experience and upon appreciation of the ways things could be, rather than upon rules and theories” (p. 117). In other words, if we as teachers wish to inculcate a sensitivity to environmental performance and building science, there is no better way than developing this experientially. In the past when integrating environmental aspects into the design studio, we have had to rely solely on precedents and thumb rules, or on the “say-so” of the expert visiting critic/tutor or testing physical models. Time constraints for the latter mean that only one or two iterations are pursued. The developmental nature of the three phases of the studio, and the co-location of digital design processes and performative design analysis seen here opened the possibility for a more hands-on experience on the part of the student.

Some of the opportunities and challenges of modelling are worth noting here. While students were able to export models to ECOTECT®, they were unable to transfer modified models back into the CAD tools of their choice. Similarly when working with the 2D ESO process, they needed to analyse options for each of the many critical cross sections separately. Students overcame their initial frustration at the lack of a two way transfer across the software by becoming more attuned to the actual results and their implications. The interesting challenge for the students was not to copy results from their separate analyses literally (1:1) into their design, but that they thoughtfully selected and interpreted those most appropriate, and continued designing with those performance-results in mind. This required a shift from a standpoint where environmental and structural considerations were technical add-ons to one where seamless integration was the goal. In addition, the perceived difficulty also reinforced the focus on decision making, which meant that the process could never be one that was simply automated or devoid of authorship.

In this studio, complexity was not wrought through an onerous brief and programmatic requirement but rather through explicit requirements for integrating an environmentally performative approach to architectural design. This departure from a traditional view of the architectural studio project as the end in itself redirects attention to the design processes and design decisions as well as final outcome. The emphasis on design process in the context of consequent design and environmental outcomes is crucial towards developing the deep learning approaches elaborated by Ramsden, (1992) where students do not merely mimic what they perceive to be the right solution or for that matter remain subservient to what is perceived as the correct formulaic mantra or technique. Although all students achieved the basic goals of integrating an environmentally performative approach to architectural design, it was clear that the most successful architectural design outcomes came from those that consistently moved “into and out of their designed space” even as they developed it through their iterative processes, always considering environmental performance, spatial experience and architectural resolution in tandem as they evolved and evaluated their designs.
4 CONCLUSIONS
In the current climate, where concerns range from effective responses to global warming to the ever widening scope of architectural curriculum content, an integrated approach to architectural design pedagogy is needed in order to produce graduates capable of synthesising the array of complex considerations they will confront. In an era of increased reliance on digital tools for performance analysis and evaluation in engineering and construction that could see architectural graduates sidelined to using digital media exclusively for aesthetic considerations of form making, the Environmental Performance studio demonstrates a way of extending design considerations into performative design inspired by nature.

The thematic nature of the selective studios offered at Masters Level meant that students took ownership of their learning right from the start of the studio. Despite initial difficulties in working outside their normal comfort zone, the experiences in this studio show that students will rise to the challenges, particularly if they find themselves in thought provoking environments that encourage innovative approaches and collaboration. Also crucial to the success of such studios is an emphasis on design process and ‘decision support’ capabilities of performance tools, accompanied by carefully structured assessments and learning activities, as well as school support for resourcing through labs and personnel. While the importance of a foundational curriculum in the areas of science and technology is upheld, there is a clear need for more staff who are capable of teaching across the subject area and as primary design tutors. The positive outcomes and student feedback indicate that that it is possible to bridge the perceived disconnect between architectural design and science/technology, and develop a designerly way of approaching environmental performance. Clearly, the capacity of the discipline area to drive new ways of understanding, and provide inspiration for design application must be pursued through experiential learning in the design studio.

5 ACKNOWLEDGEMENTS
The author acknowledges fellow Studio Leader Dominik Holzer (SIAL, RMIT and Arup) for assistance in co-running the studio, Innovation Fellows Michael Hensel and Defne Sunguroglu, both of Architectural Association School of Architecture, London and Ocean North for leading the Investigative Workshop and Paul Greenfield of Chase Live and CSIRO for assistance in field studies.

6 REFERENCES