THINKING THROUGH DIGITAL SIMULATION TASKS IN ARCHITECTURAL EDUCATION

M. FRASER\textsuperscript{1} and M. DONN\textsuperscript{2}
Victoria University Wellington, New Zealand
\textsuperscript{1}. matt.architecture@gmail.com
\textsuperscript{2}. michael.donn@vuw.ac.nz

Abstract. This study reports the activities of 80 second year architecture students at Victoria University, Wellington, New Zealand for the duration of a single trimester. A central theme in this studio is the framing of day-lighting problems into a quantifiable investigation and then addressing these through the use of digital modelling and simulation tools. This study offers an insight to undergraduate architecture students’ negotiation of digital design spaces and asks the question of how the knowledge of skill-based specialist tasks are extensible to core design studio. The mass education within a University environment of such specialist skill based techniques allows for an insight to the negotiation of quantitative and qualitative design criteria. The issue of learning skill based tasks at university level is a pertinent topic of study as the critique of such techniques is implicit to the holistic education of Architects but the level of this critique can vary greatly. This question also highlights the challenges faced to improving the design education approaches to computational thinking and applications.

Keywords. Design analysis; daylight simulation; education.

1. Introduction

Whilst daylight analyses have been previously applied to architectural applications mainly through heuristic methods\textsuperscript{1}, newer tools have made this area more accessible to design studios and CAD based environmental science courses. This paper reports the activities of an undergraduate design studio which aims to have daylighting as a central theme; where lighting comfort and quality become an integral part of design problem solving. The traditional studio environment and professional culture can create a separation between
disciplines; the design studio at the core and various specialised tasks, such as lighting or structural analysis as satellite events mainly to verify the feasibility of a design. Newer studio and teaching methods including descriptive analysis methods (Reinhart, 2006, 2009; Koutamanis, 2001) for environmental assessment have been applied in an attempt to overcome this obstacle and streamline students learning.

The undergraduate architecture degree contains several gate keeper core courses which require students to learn technical skills, develop understanding and to apply these to concurrent studio design papers. *Human Environmental Science* is one such paper taught at Victoria University Wellington NZ (VUW) School of Architecture at the second year level. The theoretical aspirations for such courses can risk being at odds with the actual level of achievement and application of design aid tools within the studio environment. The reasons for this can range from programme scheduling, cross-integration of assignments, tutorial size, tutor availability and the delivery of skills training. Whatever the issues or reasons, an effort can be made to improve the status quo and to convey the course content in a way which is more stimulating and rewarding to students.

At a time when class sizes are generally on the increase, higher levels of environmental analysis and technical outputs are becoming the norm. One concern of the authors is the effectiveness of an iterative design methodology which utilises accurate descriptive environmental analysis for students to compare and refine solutions and the given design problem at the same time. Following from this, there is a concern as to the effectiveness of skill based training resources. This is because students may acquire the required technical skills to accurately assess environmental qualities but this in itself does not guarantee a grounded understanding or adequate motivation for more adventurous or ‘creative’ solution development.

2. Background

Two decades ago the VUW architectural education programme was structured into courses that separated ‘design’ and ‘science’. The latter papers focused on simple facts and design examples, examined independently from studio design. The structured teaching of CAAD was also a separate activity relegated to communication courses. Design decision frameworks and other design methods described by authors (Koutamanis, 1993; Gross, 1994) were intended to be developed in studio projects. The structure created a separation of technical competence by way of skills training and the ‘core’ design studio. Specific ‘Integration’ projects in studio required the students to synthesise this content.
In 1996, a radical restructuring of the architectural degree saw the Human Environment and Design courses amalgamated, which addressed this concern as well as other pressures. A set of pragmatic lectures shared with Building Science and Interior Architecture classes formed the theoretical core of a poetic set of design projects in the Architecture studio. In these projects students were asked to tackle design tasks where the light, acoustic or thermal qualities were the principal focus. The projects were constructed around architectural challenges (for example “To develop a music chamber”) using well-known architectural typologies found from an examination of precedent. The focus of the course was on the students’ documentation through their design presentations not only the poetry of their idea but the calculated performance that met these goals.

The increased influence of digital applications in the programme was such that by 2003 the whole studio was digital; 3D model based set of projects with digital output of drawings. For much of the decade 1998-2008, the course benefitted from an interest by the school in additional digital craft skills coaching in the second year of study. The restructuring at VUW which took effect in 2010 separated the content back to two courses and provided the framework for the current system of integrated courses. This structure is described in Figure 1.

Figure 1. Diagram of current course structures
The current system could be characterised by an increasing focus on work processes and professional culture through pragmatic assignments as well as adaptation to updated methods of quantitative analysis. The goal is to take advantage of recent dramatic changes in the availability of CAAD and environmental analysis tools, as well as the ways in which studio culture operates. But there is still the problem of integration.

The following hurdles of detailed digital environmental assessment have been identified by the authors and others as impacting on both the level of craft and integration of the two courses:

- Special training required and time consuming to set up
- An accurate analysis requires specific environmental information
- A developed 3D model is generally required
- There can be a level of uncertainty of results and accuracy
- ‘Integration’ advice from studio tutors / consultants can be limited

These issues are typical for a range of existing environmental assessment methods. Some of the previous inadequacies highlighted (Paranandi, 2001; Ramasubramanian et al, 1999; Novistski, 1990; Hanna, 2001) revolve partially around technological availability and problematic user interfaces and processes which have to some degree been overcome. The issues are still relevant to the new course structure; but two in particular which could be addressed within the courses were that of training and model complexity. Issues of training were addressed as this is the first step in overcoming the creative limits of the applied tool. Model complexity was addressed as the recently available programs can manage complexity to the point where students are not limited by their ability to design and create complex forms.

The term digital craft is used to describe techniques which are paralleled in traditional craft processes and are used throughout the SARC223 paper and its precursors. The hurdles students are asked to overcome are reduced by using the best tool available. The training hurdle is the most critical and allows for proficiency rather than the ‘pressing of buttons’ to achieve an end result. Like any tool, understanding the obtainable results and the limits of these results requires building a working knowledge and implementation skills. Once the resulting accuracy of calculated data is unambiguous, students are likely to approach a level of working proficiency. This allows for information to be applied in a thoughtful way to influence design decisions in both quantitative and qualitative ways.
3. Studio

The following description of the studio course objectives is quoted from the course and project descriptions:

A studio based paper with a series of architectural design projects applying evaluative and critical processes in architectural design, building environmental design methods, and designing with a client brief. Principles of people-environment relationships; satisfaction and comfort; heat, light, sound....

Initially you will develop your design, and build a 3D CAD model of it, which is to be taken into the accompanying assignments in SARC 223, for the purposes of Daylighting and Acoustic analysis.

The second part of the assignment will be to continue to develop your design, and your CAD model, and to integrate into it the information you have learnt from Construction, Structures, and Human Environmental Science, and present a final scheme that is a fully worked out completed scheme.

Daylight and sunlight illumination is one aspect in particular where integration or bridging the gap can occur. The reasons for this are clear when one considers the effectiveness of quotes from great architects such as Le Corbusier, Scarpa or Khan in stimulating the poetic aspirations of students to apply themselves to the assigned design problem. One key precedent for this assignment presented and analysed in lectures was that of the Jubilee Line extension in London by various architects including Norman Foster; in particular the “Fosterino” entrance of the Canary Warf Underground Station. Through precedent analysis the students realise that there are pragmatic aspects to achieving such poetic ends; hence there may be some motivation applying new techniques which reveal how these negotiations take place within a design process.

For this course the stance on digital tools was that the closer the language and medium of communicating the poetic and pragmatic aspirations of student designs the more likely that bridging of the gap can occur. This is because the formal visual abstractions and the analytical abstraction can now approach a near seamless transfer environment. The transfer of design intentions through iterative development of abstract models creates a situation where the barrier of translation is minimised and this can encourage ‘bridging of the gap’ to occur. Recent tools have been designed to allow for such translation operations.
4. Methods for technique learning

The approach to digital tools was applied in two specific ways not utilised in previous years; CAD teaching of Revit2010 in the studio paper and accurate lighting analysis in 3dsMax. CAD learning was aimed at reinforcing the 3D modelling skills for both design development and streamlining environmental assessment through export processes. For the first time in the recent history of the course the requirement of all students to learn a CAD package for studio design was enforced. In recent years this was in effect only mandatory for the environmental assessments. Implementing mandatory 3D digital modelling in the studio had the effect of reducing the distance between the architectural design model and the analytical model.

Reinhart’s (2009) verification of a method of accurate lighting analysis in 3dsMax allowed for the first time in this course a close family of programs in which studio design, visual representation and accurate lighting analysis could take place.

A new approach was taken in the delivery of skills which addressed existing issues of demonstration and tutorial time limitations: on-demand tutorials via annotated YouTube videos. Previous experience highlighted the need for students to refer to ‘on-screen’ procedures rather than problematic and time consuming text based tutorials, whilst not relying on repeated demonstrations which would be necessary in large class sizes. The course structures limited the amount of time tutors could spend with students and so the emphasis on self-teaching and group teaching was increased.

Near the end of the studio design course specific questions were added to the regular University Training and Development Centre (UTDC) questionnaire to assess the perceived level of usefulness and integration of the skills taught through the online tutorials. Informal observations were also made through conversations with tutors and student representatives. These results and selected projects are described below.

5. Results and student examples

Informal observations regarding the students studio culture can be summarised as follows. Generally, the enforced requirement for CAAD training within the studio in conjunction with new on-demand online tutorials created a situation where individuals intensively trained themselves to a competent level within a few days of the start of the course. As time went on, the students with higher levels of confidence began assisting those who were lagging behind. The result was accelerated student-led group learning beyond expectations; at a level which could easily be described as a ‘first’ in this course and the
majority of students were able to set up accurate working lighting simulation models, albeit with simplified geometry, at an early stage.

Responses to the survey questions are summarised in Figure 2.

![Figure 2. Survey responses (N=41) ‘DDA’ refers to Digital Daylight Analysis](image)

These results reflected the students views that the analyses were useful (Q1), the online tutorials were helpful (Q2) and that assessment techniques would be used in the future (Q3+Q5). There was some disagreement between respondents regarding Q4; the majority of students would prefer some aspects of the ‘old’ system of assessment; but a proportion think that the structure introduced for the first time this year is working.

Two student examples are highlighted; accurate lighting analyses were applied to iterative design processes. Figure 3 shows modification of a dynamic roof canopy following lighting assessment which indicated high light levels and contrast causing glare. Figure 4 shows modification of a series of shaped perforations in the ground plane for a subterranean station following lighting assessment which indicated low light levels and inappropriate quality of light distribution. Both students analysed the light levels across a range of dates and times and responded to verifiably accurate simulation results through modifications which were in-line with response to brief and stated design intent.
Comments and feedback from students primarily focused on the relative accessibility of the relevant digital tools. There was a perceived isolation during the first two weeks as student activities focused on training – learning programs. When the tools were applied to a concrete design scenario, skill acquisition sped up considerably, as fellow students collaborated to improve the proficiency level for the majority. At this stage a shift occurred from following the calculation tasks given to understanding why they are performed. One analogy given was that it is like a blind person following the directions of someone else, and then being able to see.

6. Discussion and conclusions

The results presented in this paper show that the new system for integrating studio design and environmental assessment has had a positive effect in terms on student achievement and studio culture. In the past the inherent difficulties
of environmental analysis restricted the ability of students to sincerely apply quantitative analyses to iterative design processes of the traditional studio. These difficulties have not been completely overcome but the negative effects can be moderated through new digital platforms and technique based training methods. There are two ways in which the students in this new system can benefit from breaking with traditions of environmental assessment integration with design studio.

Firstly, newer methods in delivering skill based training have improved the relationship of environmental science and architectural design studio through streamlining support and encouraging group-led knowledge acquisition. The specific methodology of on-demand video tutorials introduced in a sequential manner assisted in raising the abilities and confidence of the studio group as a whole. There are still barriers to integration which appropriate technical training cannot overcome. Conducting digital daylight analyses will confront students with a large amount of information; how they use this material in reporting to tutors is of concern and may be the weak link in the chain. Also, tutors of the studio design paper have a lower skills base in the analytical techniques than is asked of the students; this is because most of these tutors from industry rely on the ‘standard’ set of architectural skills to adopt their role as design mentors. They are unfamiliar with the environmental assessment methods. Previous courses within the School have successfully used senior students as skills coaches to fill this gap rather than extensive up-skilling of studio tutors, but the dual role of design and daylight expert is a more difficult one to fill.

Secondly, the switch to descriptive analysis tools has largely removed the simplification and trivialisation which can occur with previous heuristic methods. There is also an added benefit to using a single platform which can accommodate design exploration and accurate digital analysis. The user interfaces of the newer tools allow for quick up-take of required skill set; and allow for assessment and iteration cycles in short time frames.

In conclusion, studio integration requires more than just good training of techniques, but there are tangible benefits to ‘streamlining’ the technical training process, as long as any new processes do not oversimplify the environmental science learning objectives or numerical skills.

Endnotes
1. Dean Hawkes has provided an early history of mainly heuristic methods (1970) and also updated observations (2008); Hannah (1996) also outlines methods.
3. The ‘old’ system from 2 to 3 decades ago: separate courses in design and Environ-
mental Control Systems; each with own ‘design exercises’: whole buildings, windows (daylight), fittings (electric light), energy flows (heating/cooling) etc.

4. Familiarising students with the workable capacities of a digital medium is essential but takes time and practice (McCullough, 1996).

5. The questions have been simplified for formatting reasons. The exact questions asked are as follows: (1) Lighting simulation analyses assisted the critical evaluation of design proposals in the core design studio projects. (2) I am confident that, in future design projects in the school and later in practice, I understand how to conduct an accurate lighting analysis. (3) I am confident that, in future design projects in the school and later in practice, I understand how to conduct an accurate lighting analysis. (4) Design integration in ARCI 212 would be significantly improved if the technical course SARC 223 were to focus on simple facts and design examples, examined in essays and exams. (5) I am confident that I have learned enough about the design analysis software like Ecotect that I can continue to practice on my own with other projects and develop and improve my skills on my own.

Acknowledgements

Special thanks to co-ordinators of ARCI212; Martin Hanley and Guy Marriage; tutor comments and observations for ARCI212 and SARC223 courses; Highlighted student examples; Monique Mackenzie, Alex Sawicka-Ritchie; Student representative Harriet Eberlein.

References


