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BuildAbility:
the future of construction education

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ETH Digital brick fabrication prototypes

Source: Melonie Bayl-Smith.



1. FOREWORD

The future of architectural education has been heavily contested and debated in the modern era, and possibly more so at present than in any other time in recent history. Apart from discourses on design, core to these discussions are the possibilities for new modes and opportunities in architectural practice, and the agendas and methods of architectural research. In spite of the flurry of conjecture, it remains that the main concern of Architecture itself is in the design and realisation of built environments. On this basis, there are constants that can be quickly established and readily drawn into propositions for any alternate or divergent approaches to education and practice and their intersection.

The BuildAbility research project recognises that within the frameworks of aesthetics, functionality and sustainability the future of architecture remains heavily dependent on the profession's collective and individual knowledge bases in regards to building technologies and their implementation. However, in both the universities and the profession, there is strong evidence that foundational and continuing education in construction, structures and fabrication has changed over the past two decades – and in many cases this has been to the detriment of achieving quality learning outcomes for students of architecture.

The focus of this research project is therefore to provide an international review of the approaches to providing learning opportunities and integrated teaching in Building Technology, and in particular focusing on those schools for whom design/build studios and research is a valued part of the architecture program in their school. Design/build projects provide opportunities for expanding design and integration skills beyond the limitations of traditional construction teaching, and these projects provide avenues for a closer alignment between design and technical research and the core curricula of architecture schools.

What has become clear from the undertaking of the BuildAbility research project is that in many schools of architecture, technical teaching and learning needs a strong advocate. More than anything else, this is particularly for the sake of Australia's undergraduate architecture students who face unprecedented competition and rivalling concerns both within and outside of the profession. Further, the issues facing the architecture schools are inevitably complex. Funding models as well as the cultures and attitudes of University administrators have, in turn, had an undeniable effect on the

ability of many schools in this country to provide the best resourcing for the curriculum and studios they wish to offer their students.

To research, evaluate and critique the circumstances of architectural education in light of the practice and practical realisations of Architecture involves an ability to appreciate and understand the challenges from a variety of viewpoints. It has therefore been important to avoid the agendas of a particular position, and instead review the collective and naturally varied concerns voiced by a range of stakeholders.

Therefore, the conclusions of the BuildAbility research discuss the possibilities and prospects of improving and enriching the learning opportunities in construction, structures and fabrication being offered in Australian schools of architecture. It is important to state at this point that this research has resulted in a set of recommendations more far-reaching than originally anticipated and that point towards a range of related research topics and ideas.

I wish to again thank the NSW Chapter of NAWIC for awarding me the 2010 International Women's Day Scholarship, which has afforded me numerous opportunities to expand my horizons, both professionally and personally.

I am also particularly indebted to a number of individuals, whom without their support and encouragement this project could not have encompassed the topics, people and places detailed in this report:

Piers Bayl-Smith— my husband, who is endlessly patient with me and the world of architecture, and with whom I share a deep commitment to our two wonderful children.

Stephen Gray and the staff of liquidARCHITECTURE – for shouldering the load whilst I was away from the office for a total of fifteen weeks during 2010. In particular I wish to thank Stephanie Hall and Michael Ford for assisting me in organising endless interviews, compiling information, preparing presentations, and generally providing direct support to this project.

Kirsten Orr – my mentor, colleague and friend, without whom this research idea would never have appeared on my horizons.



2. EXECUTIVE SUMMARY

BuildAbility: the future of construction education

The research project *BuildAbility: the future of construction education* was made possible through the awarding of a the NAWIC International Women's Day Scholarship to Melonie Bayl-Smith in March 2010. The initial inspirations and observations that made the research proposal a reality were borne out of her keen interest and passion for the connections between and across architectural practice and education.

In both universities and in practice, there is strong evidence that foundational and continuing education in building technologies has changed over the past two decades. These changes have occurred in Australasia in such a way that there are now distinct disparities between the learning opportunities offered by various architecture schools. This is especially evident in relation to how construction, structures and other building technology knowledge areas are taught as core subjects, and the manner in which technical knowledge is valued as an integral element of architectural design and practice. These observations, supported by recent research into architectural education in Australasia, formed the basis for this investigation.

So as to cast the net as widely as possible given the constraints of time and funding, the research project involved visitation to a number of architecture schools from across Australia, New Zealand, the Netherlands, Germany, Switzerland, North America and the United Kingdom .

Core to the execution of the research project were interviews, meetings, and reviews of curricula and school structures with Faculty Deans, Heads of schools, full and part-time academics and researchers, sessional teaching staff and workshop managers. Studio crit sessions, interviews, focus groups, a web based survey for Australian students, and reviews of student work engaged with both students and recent graduates on the topic. Meetings, focus groups and interviews were also held with architects, researchers, engineers, and writers. In support of the research, a comprehensive literature review was conducted continuously throughout the key research period particularly as different opportunities and connections began to appear from the research process. Lastly, the research was complemented by attendance at an international conference on digital fabrication.

One of the key findings of this research is the distinct need for architectural education to endorse design integration across both the design studio and individual subjects. It was evident that some schools were reintroducing design integration methods and philosophies to their curriculum structures. Other schools that had not previously applied design integration principles in their teaching exhibited increased interest or were in the early stages of implementing these in their curriculum.

Another important resolution from the research was the need for greater cross fertilisation of ideas and support between the architectural profession, building industry and the academy. Whilst this is a concept challenged by many prejudices and obstacles, it was evident from the research undertaken that in situations where these three entities had worked together, greater understanding of the needs of each stakeholder was developed. In addition, tangible benefits and outputs were more substantial, were able to be broadcast to a more diverse audience, and had greater inherent longevity and integrity.

Based on the outcomes contained in this report, the summary of the main recommendations from the undertaking of the BuildAbility research project are as follows:

- Allow architecture and engineering schools to invest in design integration programs via improved tertiary funding, cooperative programs with the professions and building industry at large, better studio and workshop facilities and diverse staffing profiles.
- Support the establishment of an Australian and New Zealand base undergraduate building technologies curriculum that allows students to develop “ideas of making” alongside the “making of ideas”. It is proposed that this would form the basis of the ARC Linkage Grant application for 2012.
- Revisit, rethink and realign desirable graduate attributes and professional competency standards by improved engagement between the key stakeholders to professions - academy, registration bodies, professional bodies, students, employers. It is proposed that this take place at the anticipated review of the AACA National Competency Standards for Architecture in 2013.
- Architectural schools to encourage opportunities to extend their building technology learning at Masters level, in both the design studio program and electives.



3. RESEARCH CONTEXT AND METHOD

Overview

The original research project context and method was generally adhered to throughout the investigative process and was only augmented and altered to further the aims of the research as new opportunities arose during the course of the project's undertaking. Detailed below are the original proposal parameters and aims, as well as commentary on those activities that were altered, added to, or not executed.

Intent and rationale

The original research project intent and rationale is set out below:

The purpose of my research is to investigate international and local models for teaching construction and fabrication principles, methodologies and technologies within university course programs in Architecture. The models to be investigated will be those where hands-on construction and/or fabrication projects are made available to University students, and/or where construction is taught as a subject and also as an integrated part of the design studio program.

As a secondary strand, a review of the current provision of CPD in relation to Construction will be conducted, including an appraisal of the informal sharing of knowledge via social media and email channels. This review will also look at the role of Industry in providing CPD for architects, and also whether the universities can play a more substantial role in providing post-study information and teaching in Construction.

By ensuring that students and practitioners of architecture have increased and ongoing learning in regards to Construction, the built environment and the community as whole could potentially benefit from this work. Improved capability in the current and future profession would also contribute to the ongoing relationship of the profession to the engineering and building sectors of the industry, as well as to government bodies. In that respect, multiple and diverse communities would thereby benefit from the long term investment that could be established and developed based on this research.

Across the duration of the BuildAbility research process, the principle purpose of the research was expanded as the possibilities of digital interfaces, and embedded practice and research specifically in relation to building technologies, were clearly evidenced during the European leg of the itinerary. Whilst investigations relating to the secondary strand were included throughout the research trajectory, the ability for the research to accommodate this strand at the level originally intended was not sustainable. This was particularly in light of the breadth of research required to satisfy the main purpose of the project. Having stated this, the considerations made of this secondary strand will be discussed in the review of professional standards later in the report.

Literature review

The literature review from the original application is included below:

In reviewing the literature relating to both Australian and international research into Construction teaching, it becomes apparent that there are some excellent and thought provoking documents about the methods and outcomes of specific Design/Build projects, problem based learning approaches or innovative teaching practices. However, the shortcoming of these papers or publications in the light of this research topic is that they nearly always refer to a single specific school of Architecture. There is little to no documented research on Construction education where a comparative study of curricula and/or outcomes has been undertaken. The only publication that even remotely attempts this is "Learning by Building" (Carpenter, 1997) which details various Design/Build projects from ten different US universities in a documentary fashion.

The Australian Learning and Teaching Council June 2008 report "Understanding Architectural Education in Australasia", authored by Prof Michael Ostwald and Ass Prof Anthony Williams (both from Newcastle University), provides an immense level of detail in regards to the various challenges and opportunities facing Architectural education. Their report identifies a number of areas where improvement is highly desirable, and also where research is required to better understand the nexus of academia and the profession.

Within this report, the authors identify that the teaching of core or discipline specific subjects (e.g. Construction, Structures) is being eroded by the rise of generic skills and curriculum overcrowding (Vol 2 p21), and staff research interests usually not being related to practical issues of the building industry (Vol 2 , p22). Further, the bulging accreditation requirements have become a "de facto" national curriculum, in place of developing specific and highly considered curriculum for each and every subject area. It is on the basis of the minimal research material available, as well as those areas identified in the ALTC report that are requiring research, that this project has integrity and credibility not only within Australia but potentially on a broader scale.

Since the commencement of the BuildAbility project, additional material has been obtained, read and considered. These materials have either supported the original intent of the research, or have supported the extension of investigations into digital fabrication.

Method

The research method from the original proposal involved the following:

- *Interviews with faculty staff regarding the teaching of construction both outside of and within the design studio, the faculty philosophy and culture in relation to construction, the current construction curriculum and history of the teaching of that subject at each university*
- *Review of student projects and built and documented output presented*
- *Review of workshop, studio and fabrication facilities at universities*
- *Review of AACA National Competency standards in relation to construction specific items and how these are satisfied at the University and practical levels*
- *Interviews with key figures in the Australian architectural profession, the building industry and engineering profession in relation to their views, opinions and expectations on the profession with regards to Construction knowledge.*
- *Review of CPD information and courses available to architects that relate specifically to construction materials, methodologies and technologies.*
- *Compilation of a “matrix” of core construction knowledge to provide a benchmark and framework for meaningful construction curricula and continuing professional education for graduate and registered architects.*

The BuildAbility project involved all of the aforementioned research activities, as well as:

- numerous interviews with practitioners, students, graduates and other professionals involved in architecture, engineering and the building industry in the international arena.
- participation in design reviews as both guest critic and as an observer

These activities served to broaden the range of opinions and experiences that could inform the BuildAbility research project, as well as provide the immediacy of real-time interactions within the studio and teaching culture of individual schools.

Outcomes

The original outcomes for the BuildAbility project were as follows:

1. Recommendations for a core Construction curriculum and teaching framework for both undergraduate and Masters degree programs in Australian schools of architecture. This will be supported by a detailed report on my research findings, with an analysis of the approach to and educational outcomes evident in the selected construction teaching programs based in Australia, the Netherlands, Germany, Switzerland, UK, and US.
2. Recommendations for a review of portions of the AACA Competency Standards with particular regard to areas of technical knowledge, including Construction and Structures.
3. Written research material in support of an ARC Linkage Project Awards grant application for 2010/11 relating to the future of construction education in cohorts with the broader building

industry, including reviewing the role of architectural practices and associated professionals in directly contributing to the education of architecture students within the workplace.

This report fulfils the first outcome and extends the original aims due to the opportunities availed during the research process. On the basis of the report being complete, the furthering of research in this area is supported by the Faculty of Design, Architecture and Building at the University of Technology, Sydney with the intention of lodging an ARC Linkage grant application for the 2011/12 period in association with other UTS DAB staff.

Additional outcomes have been realised during the course of the research period and indeed beyond. These are as follows:

- Invited to speak at Archivision2010, an invitation-only conference for leading practitioners and academics, organised by the Australian Institute of Architects. At this conference I presented a paper called “Embedding practice in education: an international perspective” which reflected on the work of practices undertaking design/build oriented research as an embedded entity within university structures – this will be covered within this report.
- Seminars presenting the initial findings and observations of the BuildAbility research project to several Sydney Architects Network Groups .
- Presentation at the NAWIC International Women’s Day 2011 event, providing a summary of the research project and the recommendations being made on the basis of the research.
- With Dr Joanne Jakovich, Senior Lecturer at UTS DAB, co-editing a book conducting an international review of collaborative learning in architecture via design/build studios – intended publication 2012.
- Invited to conduct a workshop related to the outcomes of the BuildAbility project at FLUX, the 2011 Australia New Zealand architecture students congress.
- Invited to write and coordinate a Spring Semester M.Arch. elective studio at UTS DAB based on design/build investigations, material properties and assembly concepts.

Funding Source

The BuildAbility research project received the 2010 NAWIC International Womens’ Day Scholarship (\$16,000), and had prior to this also been awarded the 2009 Byera Hadley Travelling Scholarship.

Itinerary and time frames

As would be expected for any research project with a significant travelling component, extensive planning was required in order determine the best arrangements for travelling to the various countries and universities. So as to investigate the realm of possibilities early in the project, the bulk of these organisational activities took place in March through to early September.

The final time program is located in the Appendix and the list of schools and institutions directly visited or with whom direct contact was made with staff, graduates and students is as follows:

Unitec Auckland; University of Melbourne; Monash University; University of Newcastle; University of New South Wales; RMIT; University of Sydney; TAFE NSW – Architectural Technology; University of Tasmania; University of Technology Sydney; University of South Australia; Victoria University Wellington; TU Delft ; TU Stuttgart; Stuttgart SAAD; TU Berlin; TU Muenchen; ETH Zurich; University of Toronto; University of Michigan; MIT; Harvard GSD; University of Bath; University of Cambridge; Architectural Association; University of East London; and London Metropolitan University.



ETH, foam digital fabrication sculpture. *Source: Melonie Bayl-Smith.*



4. INTRODUCTION

Construction. Structures. Fabrication.

These three words, mentioned in the context of architectural education, are almost always guaranteed to ignite vibrant debate amongst those who teach in schools of Architecture - or alternately, those who are committed to architectural practice. Or perhaps those who work in a related field or in the broader building industry. Or maybe even those who attempt to occupy several roles both within and outside the profession as it is most commonly understood.

To demonstrate, and to set out the initial parameters for this research project, we could pose three questions:

“What place do construction, structures and fabrication deserve in architectural education?”

“What level of knowledge in construction and structures should be established within our desirable graduate outcomes for students of architecture?”

“Should it be compulsory for students of architecture to demonstrate in each and every year of their studies an increasing sophistication in technical knowledge and design resolution skills via integrated project briefs?”

But further to these questions and provocations, a point of possibly greater interest and has been highlighted by this research project. In reviewing the place of building technologies within the field of architectural education, immediate connections are created to most, if not all other parts of architectural education. This leads all the way to asking:

What constitutes an architectural education?

To extrapolate: on the one hand, it is well understood and accepted that design is absolutely core to an architectural education. So when we ask questions about everything around, under and over design, it immediately raises a line of enquiry about curricula, about the culture of architecture schools, about the responsibilities of the profession, and about the culture of Architecture itself. By investigating the teaching or act of designing, one can choose to strip away all of those practice, history and reality-based elements that may be otherwise integrated with the process, or indeed the end result of design. It could be argued that this disconnect converts the act of design into a purely object or idea-making exercise, an end unto itself.

Conversely, it is possible that building technologies can be researched and developed as an end in and of themselves. However, once these technologies and ideas are put into play, moving away from the realm of the example, the standard, or the ready-made, their application in the process of design integration quickly brings to light the interdependency of all elements of architectural practice.

This is where we often hear practitioners say that construction - or perhaps more specifically articulation, materialisation and specification – is design, and that determining these supports the concept of ‘Design as Research’. Looking closely then at articulation, materialisation and specification as key concepts, one is brought to the connections between tectonics and design as the basis for architectural making and building. In applying these concepts to architectural education, enquiries have then been invoked about course curricula, the cultures and agendas of architecture schools, the responsibilities of the profession at large, and about Architecture itself.

It was over a number of years of participating in or observing discussions around these topics that I was spurred on to pursue this research project. The topic arose at different times – daily work in practice, interviewing job applicants, at local architects’ network groups, seminars and conferences, whilst teaching at different universities, examining candidates for the Part 3 registration exam, mentoring students and graduates alike – the list goes on. To therefore review and knit together these observations with those from the research project, the outcomes are broken down into the following components:

Curricula, competencies and professional standards will contain observations made of the determinants of curricula and competencies for architecture schools, both internationally and within Australasia.

Learning Opportunities: Construction, Fabrication, Structures will look at what these subject areas comprise and how they are being connected to various types of learning opportunities developed and offered at various schools of architecture

Design/Fabricate/Build will specifically focus on the development of the design/build studio concept, and those schools where this has become a key component in teaching and learning within the architecture program.

Design Integration will review the possibilities of design integration models as observed during the research process and will reflect on the opportunities and challenges of this approach to curriculum, teaching and experimentation in design.

Materials and Assembly will consider how material language is explored in architecture curricula, how material research influences building technology teaching, and also reviews the spaces and places within which material exploration has been observed during this research project.

Embedded Practice will look at those schools of architecture where the melding of practice with research, teaching and built outcomes influences the culture of that school and increases the tangibility of the design teaching and research via its capacity to demonstrate physical, built outcomes.

The **Conclusion and Recommendations** will summarise the findings of this research project and propose recommendations for further research and action.



5. CURRICULA, COMPETENCIES AND PROFESSIONAL STANDARDS

One could posit that architectural education will always move towards ideas, hypotheses, and the possible futures of architecture - and by way of this approach, it has a limited accountability to the profession and its daily realities. From that sort of position it is not difficult to see where technical teaching and learning might not be given priority in the agendas of a school of Architecture, possibly in spite of the best intentions. The converse view might be that only seasoned practitioners can truly evaluate the effectiveness of architectural teaching, as practise is the ultimate 'road test' for architectural skills and integrated knowledge, and the only realistic vehicle for the ongoing development and refinement of these in the practical context.

It is at this nexus of the professional competency standards and desirable graduate outcomes that curriculum ultimately comes into question, and by way of this question, those resources and forces that contribute to the delivery of a curriculum.

The most outstanding research undertaken on this exact issue is Michael Ostwald and Tony Williams' research project entitled "Understanding Architectural Education in Australasia" (2008). As concerning as the material in the two-volume report may be to academics and practitioners alike, it has been key in affirming the intent of the BuildAbility research project and the need for an examination of the place of Building Technology teaching in Australian architecture schools.

From their introduction, Ostwald and Williams move straight into the territory of responsibility – who is responsible for the guidance, curriculum, and future of architectural education? They describe architectural education as being like "a square piece of fabric", being "held" at each corner by one of the four key stakeholders in architectural education: the registration bodies, the profession, the community and the universities.

Ostwald and Williams identify that over the past fifteen to twenty years, the changing nature of the demands on and the needs of these four stakeholders has placed enormous strain on the "piece of fabric", and what has emerged from this situation is that the expectations of these entities on all other stakeholders has altered such that "...for the last decade, the positions of the four stakeholders have become increasingly entrenched and most of the groups act as if their needs outweigh all others."

As an example, this preceding statement might apply readily to some schools, where the 'Making of Ideas' takes substantial precedence over the embrace or teaching of 'Ideas of Making', beyond the

most cursory review. This downplaying of the need to expose students to some measure of real-time skills and knowledge for the practise of architecture is staggering, especially to the outsider.

In contrast, problem based learning or design integration models have historically demonstrated that they are capable of providing a balanced and opportunity-laden course of study for architecture. This is as opposed to strict “atelier” and “liberal arts” type models which have predominated in some Australian universities in the past, and are still the model of choice in some internationally renowned universities. However, in the current teaching and economic environment, and according to anecdotal evidence that emerged from the many interviews conducted for this research project, these ‘deep immersion’ design integration models are apparently too resource intensive for many Australian universities. Roughly, this translates as design integration models being too draining or unachievable with the available funding and staff resources.

Consequently, I would like to reflect on four core recommendations made in Volume 2 of Ostwald and Williams’ report:

Recommendation 3 clearly identifies the many problems inherent in the competency standards documents for accreditation and registration, which in turn create myriad opinions from both practise and the academy in relation to what an architecture graduate should “look like”. From the standpoint of this research project, most examiners for the APE Part 3 can and will attest to the inability of the registration process to adequately test candidates’ knowledge in relation to building technologies. Whilst the log book and mandatory competency requirements result in a certain level of construction knowledge and exposure being gained by any candidates, it remains that the “gatekeepers” for instigating and developing the knowledge bases of students and new graduates are practises and the schools of architecture. Considering the variability of both entities and also the NVP and SVPs visits, there is presently no way of assessing the technical knowledge of the typical graduate.

Recommendation 6 talks about the move away from core skills in the curriculum (such as Building Technology, documentation and other technical knowledge areas) towards teaching generic skills, which an architectural education tends to develop anyway when the core skills are being taught and integrated well. The key concern here is integration – an inherent trait of practise – but also the need to combat architecture’s image as a discipline taught by ‘rule of thumb’.

Another issue that arises from this recommendation is that individuals who are interested in teaching technical subjects are usually practitioners. In most cases, practitioners do not wish to pursue a full time academic career nor the almost universally requisite PhD, which has somehow become a measure of the ability to teach - as opposed to a measure of the ability to conduct meaningful research. Over time, this has by and large marginalised practitioners to the domain of sessional tutoring, and caused fractional and full time academics to struggle with maintaining or being part of any kind of meaningful practise with built work. Therefore there is little wonder as to why, Australia wide, there is such a small pool of academics who have both solid practical experience and the desire to provide powerful and innovative building technology learning opportunities to architecture students.

Recommendation 10 calls for the support of the design studio as it is the focus of architecture programs in Australia. In terms of physical spaces, the fight for retaining and expanding design studios has occurred endlessly in universities around Australia. In some cases, it has been only with the intervention of local members of the profession and the Institute of Architects that some schools have successfully kept their design studio spaces. Having noted this, it is in these spaces that critical learning occurs, predominantly peer to peer and collaborative learning, and if design integration is not supported as a vehicle for architectural education, then the design studio will continue to be threatened by the external forces of the university hierarchies.

Lastly, **Recommendation 13** talks about industrial experience. In the past, students generally obtained their industrial and practical experience in one of three ways: that their experiences ran parallel to their architectural education like an apprenticeship, they were gained in concentrated year or two out between their architectural degrees, or their architectural education was complemented with time spent working for builders or otherwise “on the tools”. The current day situation with the relatively new Bachelor-Masters structure is such that experience gained “in the field” is no longer mandatory or considered highly desirable in order to progress from one degree to the other, nor to even graduate. There is also little encouragement for students to consider obtaining experience outside of the strict realm of architecture, whether that be in hands-on building, project management, manufacturing, art and design, or media.

Further to these concerns which ultimately have an impact upon the curriculum that is assembled and delivered within any given architecture school, there have been many anecdotal and direct observations made within the trajectory of the BuildAbility research project that support the research undertaken by Ostwald and Williams. A notable comment from a long-serving member of staff from one Australian university (which at their request will be quoted anonymously) was as follows:

“When you see something good from which students benefit, but there is no interest in perpetuating it, this is problematic in terms of building a meaningful culture within a faculty, as well as providing something that will hold students’ interest and will attract people to study [here].”

AACA National Competency Standards in Architecture (NCSA)

The NCSA consistent of four competency categories being Design, Documentation, Project Management and Practise Management. These categories are divided into 12 Contexts, 45 Elements, and 149 Performance Criteria. For reference, the AACA have placed this multi-tiered structuring of the Competency Standards against a traditional model of architectural practise. In doing so, the standards are “regulated” in such a way that they can be applied and tested in the AACA registration examinations. This is made explicit to registration candidates with regards to the competencies against which they log experience in the Log Book (submitted as Part 1 of the APE), and must also be prepared to ask questions upon in the Part 3: Interview. The competencies are, in

essence, the framework for the accumulation of appropriate experience and the means by which they must distil these experiences in order to apply and sit the registration examinations.

Over time, however, the NSCA has become a default checklist against which architecture schools in Australia, and in the near future New Zealand, have their curriculum reviewed on a regular basis by the National and State Visiting Panels (NVP, SVP). Having not being developed for this purpose, but nevertheless adopted for such an application, the NSCA and its long list of performance criteria become a “pick and mix” of points that more often than not relate to the key competencies in the most vague and ill-defined of ways. In effect, the competencies can then be reduced to a selective group of criteria that, regardless of coherency and relevance, are on paper still satisfying the competencies required to be encompassed by any given curriculum for architecture degrees in this country.

It is difficult enough that Part 3 examiners, when passing candidates for the registration, are effectively verifying that the candidate satisfies all 149 Performance Criteria in the NSCA. This might seem a facetious statement, but it is effectively the truth. This statement also highlights the long, flabby list that the NCSA has become and from which a rigorous, well-rounded curriculum would struggle to be effectively and concisely drawn, much less reviewed for the accreditation of architecture schools.

What is also troubling about the NSCA is that the allocation of elements to particular contexts and competencies, whilst well intentioned, pulls apart the practise of architecture in such a way that the integration and continuity inherent in practise is somewhat forgotten, with the natural overlapping, feedback loops, and iterative processes ignored by the repeated inclusion of almost identical elements and performance criteria in the NSCA.

As an alternate to overhauling the framework and intent of the NCSA, should the profession decide that it does not wish to constrain the universities with fewer, more concise and non-negotiable performance criteria, then there needs to be found a better way for understanding where the profession is headed and what registration means for the future profession.

Internships

Whilst conducting research for this project, the issues surrounding the graduate “gap”, registration, and real time practise experience arose on a fairly frequent basis. Key to these discussions were the possibilities and challenges of formalised internship programs and what these contributed to both student’s ongoing learning as well as graduate outcomes and the skillfulness of the architecture profession as an ongoing concern. For example, in the Netherlands, graduates are required to complete formal internships, and these internships contribute to the registration process for architects in that country. The formal nature of the internship is important, as very few students work at the same time as studying architecture. This is largely due to the university workload, design expectations, and their significantly longer academic year with only a 6-8 week summer break.

In contrast, in Britain Parts 2 and 3 of the registration examination, which include a formal internship component with competency goals and requirements, is integrated with the teaching at the schools

of architecture so that there is a necessary connection between profession, registration bodies, practices and the academy.

As a comparison, in the North American universities students tended to pursue summer internships in order to obtain practical experience and culturally it is typical of most architecture schools to openly encourage students to do so. This approach to obtaining practical experience can also be attributed to the very heavy coursework load that is typical of universities in the US and Canada which is a product of their very long summer break and the fixed exam periods in the university calendars.

In Australia, whilst practical experience is absolutely for registration, and time spent working during studies can be included in candidates' log books, the need for students to undertake practical work experience during their time of studying has become a matter of personal choice and circumstance, rather than a dictum of the academy, or the profession, for that matter. Included in this realm of personal choice and circumstance are issues such as the cost of living, the opportunity for better/more pay working in hospitality and retail jobs, preoccupations with lifestyle maintenance, time spent travelling each week, lack of contacts, language and visa barriers – the list goes on.

An interesting observation has been made in relation to these issues, both independently and jointly by a number of different local Sydney practitioners and graduates interviewed for this research project. This observation was that if students are not able to access work experience in architecture because of the cost of living, the need to earn better money, and problems of proximity and accessibility, then the profession and the universities need to be able to better serve students to broaden and deepen their graduate work opportunities.

How this might be achieved is yet unclear – in some smaller universities, such as UTas, a student staffed, registered architectural office has been set up in the past year – with real projects and real clients. Whilst there are reasonable doubts that such a model would work in Sydney, perhaps formalising internships is a timely vehicle for improving the relationships between the architecture schools and the broader profession.



6. LEARNING OPPORTUNITIES:

CONSTRUCTION, STRUCTURES, FABRICATION

Building Technology and its place in the curricula of architecture schools and programs is contentious, as previously illustrated in this report and evidenced in the many interviews and discussions held for this study. On a purely base level, the sheer range of topics and intersections that construction, structures and fabrication have with other elements of practise and design is sufficient to create uncertainty, especially where schools are often already concerned with “overcrowding the curriculum” and the competing concerns of teaching and research.

A list of these topics might be as follows:

- construction typologies
- structural systems
- materials
- assemblies
- standards
- energy use and management
- sustainability
- building services
- building systems
- documentation
- digital interfaces
- BIM
- fabrication methods
- site management
- safety
- costing
- programming
- sequencing
- prototyping
- etc

Considering the breadth of the prior list, it would impossible to cover these in any reasonable course of study, let alone one that has as many demands on it as an architectural degree curriculum. What

can draw many of these topics together is the teaching model and learning opportunities which serve as the vehicle for conveying this information. It can therefore be argued that building technology teaching depends heavily on purpose – a design project, case studies, site visits, contexts, qualities, historical precedents – so as to link the technical language of architecture with the design language of architecture.

In speaking of a tectonic language of architecture and the teaching of this language, the best example of looking at this in an elemental fashion is the work of Prof Dr Andrea Deplazes. Prof Deplazes is tenured at D-ARCH (ETH Zurich), and is best known outside of Europe for the “best-seller” *Constructing Architecture: Materials, Processes, Structures*. What is fascinating about this book is that it is a very real and accessible research outcome, rather than simply being a collated volume of technical facts. The book came into existence after a number of years of teaching construction at D-ARCH, and effectively the book comprises the intent and material from the lecture outlines that Prof Deplazes prepared for his students year after year. The success of this book is in its gently instructive nature, addressing an exhaustive range of topics relating to the construction, materialisation, articulation of architecture. It allows the reader to establish an inner “language” of architecture so that they have the tools to both design, understand building technologies, and therefore expand their architectural “vocabulary”.

The diagram below demonstrates Deplazes’ approach to the place, practise and teaching of construction within architecture. The circular form of the diagram is not only useful to show the potential placement of these elements with each other in relation to project form, but this could also demonstrate the potential for both the integrated teaching of construction and design.

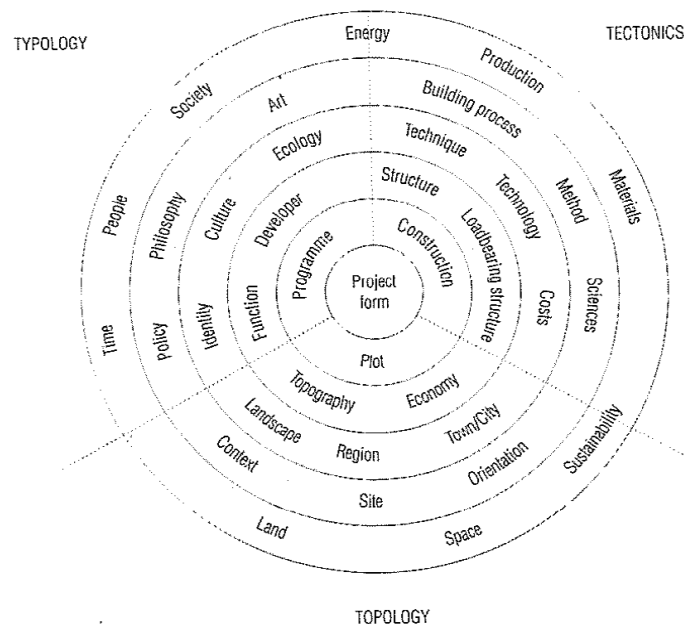


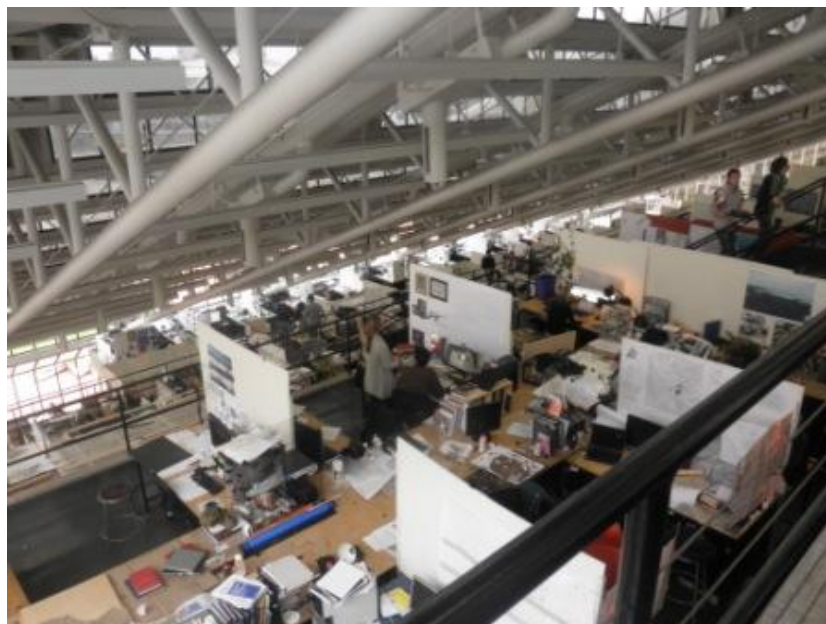
Fig. 1: Form-finding or form-developing processes

Diagram mapping the concerns of architecture and construction Source: Deplazes, A. *Constructing Architecture: Materials, Processes, Structures*

In reviewing this diagram, perhaps a good starting point in terms of providing the platform of purpose is to frame Construction as another way of solving a design problem and that alongside the development of design skills comes the development of technical knowledge. This sort of integrative learning would appear to be best absorbed by projects of increasing complexity and size being introduced to the design studio.

Alternately, a design project could be set up with “zero program” and instead be developed with an emphasis on material considerations, structural systems, and other tectonic realities and devices - so as to engage differently with the usual constraints of the architectural project. This might be a way of looking at the “construed” against the “constructed” from a theoretical point of view.

Beyond this however, it is without doubt that like the design studio, teaching and learning in building technology is best served by the student being involved with a range of representational modes and exploratory activities that also develop a sense of scale and tactility - sketching, drafting and drawing, including at 1:1; physical and digital modelling; fabricating; prototyping; hands-on building; etc. Again, this is where design integration models and design/build studios provide an excellent complement to the traditional delivery of construction knowledge.



GSD Studio *Source: Melonie Bayl-Smith*



7. DESIGN/FABRICATE/BUILD

A key focus of this study has been the design/build project or studio, and its demonstrated capacity to push the boundaries of the teaching modes and learning opportunities for construction, structures and fabrication. In order to make a balanced assessment of the characteristics and reasons for success with the schools visited for this project, staff and researchers were interviewed, as well as workshops, school culture and curricula appraised, and student crits and classes attended. Even after only visiting several of the schools listed in the itinerary, it became evident that there were numerous common threads of experience that emanated from these design/build studios:

- Students were almost always extremely positive about the experiences and construction learning they gained from participating in design/build studios
- By working at 1:1 scale, students were confronted with the realities of their design decisions and this engendered a range of learning experiences not typical of the design studio
- Students felt they had gained an appreciation for the act of building and making, and also for those skills required to build well
- Students were exposed to technologies, processes and practises they might not otherwise ever experience and by way of this were given opportunity to develop their design thinking.
- That these studios were a potent way to demonstrate practicalities within the architecture curriculum because of the student-driven outcomes
- That multidisciplinary models can be readily demonstrated in design/build projects
- That these studios proved to be an excellent vehicle for connecting the school of architecture with external entities, examples being: other faculties within the university, manufacturers, consultants, local government, local practitioners, and not-for-profit and community groups
- That these studios were able to be linked to research being undertaken within the school of architecture or in conjunction with other faculties, investigating everything from material properties and materiality, structures, assembly, through to design education and collaborative learning
- That in spite of the many positive outcomes and end results, design/build studios were often confronted with the issue of proving their “academic worth”
- That the cost of finding the right teachers, materials and facilities for design/build studios is questioned predominantly where there is little to no support for making within an architecture school.

In support of these observations, a brief review of the most compelling examples visited and reviewed are set out below:

TU Delft International Façade masters

Because of its size as an architecture school, TU Delft has been able to establish an array of higher-degree courses, including vibrant research-oriented Masters programs. One the most fascinating and multidisciplinary programs is the Façade Design Program, offered by the Façade Research Group. Because of their diverse backgrounds, the members of this Group teach in various roles across the faculty, provide research opportunities and expertise to students and industry alike, engage in research projects with both academics in other institutions and with practitioners, and connect with the broader profession via exhibitions, lectures, and publications.

A key part of the output from the students enrolled in the International Façade Masters is the design/build component of the curriculum, where students design and build 1:1 scale prototypes, models of facades and experimental cladding systems and surfaces. The most experimental of these investigations are published and exhibited, providing an external outlet for the program and in turn its design/build approach.



Source: Blow, Marcel (ed.) et al. 2008, 'Imagine 02, Deflateables', Diezkeure, Brugge

TU Berlin

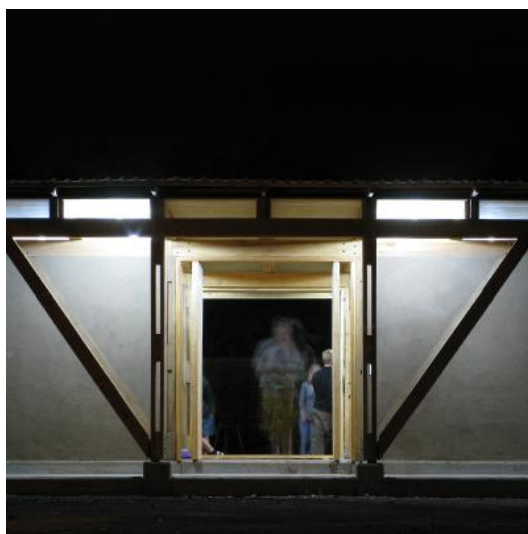
Over the past thirteen years, architecture students from TU Berlin have been offered the opportunity to participate in a design/build studio conducted in Mexico. The Mexiko Praktikumseminar was set up by Prof. Ingrid Goetz after she had visited Mexico with two students and designed a house for a community which was then built. This project was presented to the other students in the faculty upon their return to Berlin, setting off a snowball effect that resulted in the ongoing popularity of the studio. To date, the Mexiko Praktikumseminar has had published numerous booklets of the completed projects, had extensive media coverage and produced several DVDs of the projects in progress and at completion. Having said this, in spite of its track record, intent and popularity with the students, the studio faces constant battles to gain funding, particularly since Prof. Goetz retired several years ago.



Mexiko Praktikumseminar Source: <http://www.a.tu-berlin.de/mexico/>

Being a full year subject, the Mexiko studio is able to take the place of the compulsory internship required of the German education/professional system, which at times has assisted in “validating” the place of the studio within the curriculum offerings of TU Berlin. The students who enrol are responsible for the design, documentation and realisation of the individual project, part of which is travelling to Mexico for three months to undertake the build with students from UNAM (The National University of Mexico).

In speaking to Ursula Hartig from TU Berlin, the potency of this studio is partly believed to be wrapped up in the possibility of adventure- that architecture can take students on a journey. For those who have been involved with teaching in this studio, it is also seen to provide alternative exploratory opportunities to students, in that they can test the appropriateness of architectural solutions by tectonics and their execution in the design/build scenario. This has included utilising the design/build project as a platform for experiential building performance research, especially in relation to climate, experimental construction, handmade units (bricks etc), and built in furniture.



Mexiko Praktikumseminar Source: <http://www.a.tu-berlin.de/mexico/>

The Mexiko project was also one of the instigators for CoCoon (Contextual Construction) which ran from 2005-08 as a body for teaching, research and practise in an intercultural and interdisciplinary context. CoCoon's intent was to utilise the design/build platforms for a range of outputs:

- **Teaching:** CoCoon offers seminars related to the theory, the design, and the construction of architecture and settlements in a mainly vernacular context. It assists student-research and investigation and stimulates intercultural exchange.
- **Research:** CoCoon claims to investigate and research forms of vernacular architecture all over the world and to analyse its contextual, social and sustainable aspects.
- **Practise:** CoCoon is based on and related to the design, planning, calculation, and erection of buildings for poor communities in a vernacular, rural and periurban context, done by students. The work bases on interdisciplinary, international and intercultural cooperation.
- **Networking:** CoCoon is convinced about the high outcome of practice- related intercultural student-projects and offers a cooperation base for execution projects, seminars, exchange of knowledge, people and contacts.

Whilst CoCoon as an entity are presently dormant, the aims of such an organisation are of interest for this research project, in that they demonstrate the depth and breadth of thinking that is a potential outcome from a design/build studio.



Mexiko Praktikumseminar Source: TU Berlin website

ETH

At ETH Zurich, design/fabricate/build studios, projects and research occur across several of the research and teaching groups within the faculty. This area conducted at the level of exploratory scale models and experimental prototypes through to full scale conceptual constructs and real-build aid projects. Across the various interviews undertaken at ETH, it transpires that the general philosophy within the school is that making occurs equally as a mode of thinking as much as a physical action.

These ideas of making are enabled throughout all subjects and studios, hence the variety of output noted previously. Here, design integration appears as much in the robot brick fabrications of Gramazio and Kohler as it does in the exploratory bricolage assemblages from the work and design studios of Tom Emerson.



ETH and Gramazio and Kohler robot *Source: Melonie Bayl-Smith*



ETH and Gramazio and Kohler robot *Source: Melonie Bayl-Smith*

Prof Andrea Deplazes notes that form and matter need means of representation, and that making and design/build activities allow points of reference for students by way of creating an architectural language that is potent and tangible. It was also observed, in viewing the output of various studios and the research of Gramazio and Kohler, that the assemblage that takes place in both design and in construction removes students from thinking of surface as a 'solve all'. Within the design/fabricate/build studio, assemblage and the act of assembly forces thinking about structure, surface, thickness and the "inner" space of a formal proposition.



ETH and Gramazio and Kohler *Source: Melonie Bayl-Smith*

Beyond these projects are real build projects as diverse as the New Monte Rosa-Hütte high alpine construction project and the ETHiopian project. Whilst the former is a highly expensive and exclusive project, and the latter part of an aid project in the Third World, what is common to both projects, like many design/fabricate/build projects undertaken by ETH, is that they partner internally with researchers and students, and externally with industry and community members. This level and diversity of engagement with the broader community is something that should be on the list of aspirations for any architecture school, both here in Australia and internationally.

Victoria University Wellington (VUW) and the Solar Decathlon

Possibly one of the most rigorous design/build program opportunities available to architecture and engineering students is the biennial U.S. Department of Energy Solar Decathlon, with the inaugural competition held in 2002.

The Solar Decathlon is an award-winning program that challenges a shortlisted group of twenty university teams from around the world to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive. The purpose of the competition is to provide an educational experience for students, profession and public alike, using the integrated design/build experience as a platform for this experience. In turn, the competition has provided the opportunity for professional development workshops and has been published widely through various media, establishing the worldwide reputation the competition enjoys. Whilst achieving optimal energy production and efficiency is core to all of the final designs exhibited, the winning design must also achieve affordability, consumer appeal, and design excellence.

Some universities, such as the 2007 and 2009 winners TU Darmstadt (Germany), have framed entire sections of their architecture teaching program and research around the Solar Decathlon brief and the competition requirements.



TU Darmstadt. Solar Decathlon entry 2009

Source: www.o2t.de

For most competitors, however, entering the Solar Decathlon requires serious consideration: should their preliminary round entry be successful, the resourcing necessary to continue on and potentially build their design is significant. This is particularly as the competition exhibition is erected in the United States on the National Mall in Washington, D.C. For Victoria University Wellington, this is their reality in 2011, with their shortlisted design known as 'First Light' currently being constructed so that it can be disassembled, reassembled, disassembled again, and then shipped to the US in time for the late September 2011 exhibition and competition.



VUW Solar Decathlon entry original model

Source: Melonie Bayl-Smith

In July 2010, when speaking with senior lecturer Guy Marriage, who is a VUW Faculty advisor to the FirstLight House project, the school had only just been informed of it is shortlisting for the Solar Decathlon 2011. The brief had been run as a project within the construction subjects in the school of architecture and the models submitted by the various student groups were on exhibition at the time of visitation. This exhibition gave excellent insight into the knowledge base contained within the student body, and the possible learning outcomes from undertaking a rigorous construction modelling and prototyping exercise. It was clearly evident that much pride would be taken in the FirstLight project, as this is the first submission to the Solar Decathlon from anywhere in the Southern hemisphere.



VUW Solar Decathlon entry 'FirstLight' under construction Source: www.firstlight.ac.nz

MIT

At the Massachusetts Institute of Technology (MIT) School of Architecture and Planning, design/build work by students and staff alike is produced in a variety of places and spaces, both physically and also as a product of the curriculum and research occurring at MIT.

In support of the making and design/build projects going on at any one time, there are workshops both within the architecture school and off campus, just down the road from the MIT main campus, including the Rapid Prototyping Lab (RPL). All of these are supported and managed by long-term, committed staff who seek to engage with the student body by assigning leadership and responsibility to interested and capable students, the flow on effect from this being peer to peer communications and learning both within and outside of the workshops.



MIT workshop Source: Melonie Bayl-Smith

There are two workshops located at different points between the main school lecture and studio spaces, which are viewed from corridors and studio spaces alike. With a high level of visibility and easy access from the studios, it is not uncommon for students to be sharing the workshop spaces whilst working on different projects. This allows for sharing of information and collaborative design and review opportunities. These two workshops accommodate “heritage tools” (traditional woodworking tools) through to 3D printers and laser cutters. In addition, the larger workshops, both off and on campus, accommodate a range of rapid prototyping machines including laser cutters, CNC routers, a Z printer and plastic moulding facilities.



MIT workroom Source: Melonie Bayl-Smith



Digital fabrication machines – plastics moulding, MIT Source: *Melanie Bayl-Smith*

Beyond student investigations with modeling, prototypes and making projects, some staff at MIT are also utilising design/build as a vehicle for research trajectories. Associate Professor John Ochsendorf is a structural engineer at MIT and holds joint appointments between the Departments of Architecture and Civil and Environmental Engineering. His research group has undertaken a series of experimental masonry vaulting projects both within the school as well as in other places and countries, including most recently in Cambodia.



Vault201, at Cooper Hewitt Design Museum, NY Source: <http://vaulting.wordpress.com/>

An excellent example of his research interests is demonstrated in a design/build project entitled Vault201, otherwise known endearingly as the MIT “shitbrick” project. Vault201 was exhibited at the Cooper Hewitt National Museum of Design in New York and was viewed during the travels for this research project. The bricks of which Vault201 is comprised are made out of 100% post-consumer and post-industrial recycled material, including 30% processed sewage wastes, by-products of open pit-mining operations recycled glass, virgin ceramic scrap slated for landfill, and industrial dust filtration contents amongst other “components”. The bricks were put through several prototypes and trial builds of the assembly before the final vault was built insitu at the Cooper Hewitt. The project therefore not only investigates structural form and complex geometries in masonry, but addresses issues of sustainability, materiality and social responsibility whilst integrating design/build opportunities for students and researchers alike.

University of Michigan

At the University of Michigan, Ann Arbor, the Taubman College of Architecture and Urban Planning has become a place of learning and research where making is high on the agenda. This can be partly attributed to the arrival of Monica Ponce de Leon as Dean of the school, who brought with her the interests of her own research and also her former practice Office dA.

In visiting Taubman College, the research activities included interviews with a number of staff at the school, as well as participating in Graduate review crits and tutorials, visiting the workshops, and observing robot fabrication. From the observations and interactions of these activities, it was patently clear that the deep interest in exploring materiality, making, assembly and assemblage moves beyond special focus studios or the domain of experimental research at this school of architecture.

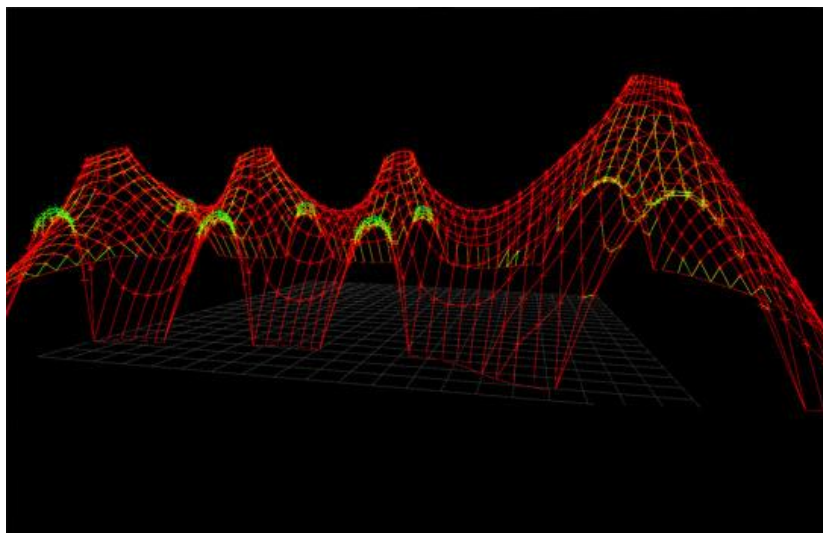


Detail from Graduate Studio “Threshold”, Taubman College *Source: Melonie Bayl-Smith*

Possibly the clearest indication of this commitment is Ponce de Leon's decision to establish in 2009 the Research Through Making grants program. Her introduction to the program was as follows:

"Historically, research and creative practise have been constructed as "opposites." This is not an unusual struggle in architecture schools, particularly in the context of a research university. Moreover, this perceived tension between design and research is indicative of an age-old struggle within the field of architecture to understand its own nature as an "applied art." The boundary between the "art" and its "application" has always been an existential crisis for the field. In some instances, design can be a purely creative activity not unlike creative practises in music and art. In other cases, design can be a purely problem solving activity, not unlike research in engineering and industrial production. The boundaries between these activities are never clear, since their methods and techniques in the context of design are ultimately very similar. [The program] seeks to set aside these struggles by acknowledging MAKING as the common denominator that cuts across the imaginary boundaries between design and research."

One of these grants was awarded in 2010 to Wes McGee, Maciej Kaczynski, and Dave Pigram for the Re:Vault robotic fabrication project. Whilst at the school for the BuildAbility research project, the stone proposed to be used in the Re:Vault pavilion was delivered to the workshop and its material properties reviewed concurrently with the making of testing models and the like.



Digital image of the Re:Vault design Source: http://taubmancollege.umich.edu/resources/research_outreach_and_funding/research_through_making_grant/kaczynski_mcgee_pigram/

From projects such as Re:Vault, the FABlab team take robotic fabrication into the graduate program, with their cutting edge research bleeding into the teaching and the output gained from students investing themselves in fabrication, computing and material investigations.

In grappling with the idea of utilizing robots in architectural workshops, it is important to note that the use of robots and digital fabrication machines does not remove the human. Rather, it places them in a different role, and allows other interactions and thinking to happen. From the observations made at not only Michigan, but also at ETH Zurich and Harvard GSD, the lessons that apply to all manner of construction, including tolerances, planning, sequencing, and the resolution of form and materiality, arise in the robot and digital fabrication realm. This is made obvious with the challenges that surround the realisation of complex geometries and their resultant forms.



Digital fabrication pavilion, detail 2009 – UMich Source: Melonie Bayl-Smith

In interview with Wes McGee, Maciej Kaczynski and Dave Pigram, discussing both their research and teaching, what comes to the fore is that whilst the robots themselves are relatively generic, the digital interface with these robots and the fabrication opportunities that exist offer a broad scope for research via making. As the use of robots in this realm of architectural research is still relatively new, their use also raises new questions about construction, fabrication, modularity, sustainability and mass production, as much as raising questions about design as research, research/teaching interfaces, and the accessibility of these projects to the broader architectural profession.



Re:vault model and robot in rear ground Source: Melonie Bayl-Smith

For example, whilst emergent technologies and digital fabrication provide a vibrant platform for design integration curricula and design/fabricate/build projects alike, they highlight construction problems in places where manual construction techniques and approaches might be more forgiving and less time consuming. Robot fabrication takes core issues of construction practise, such as understanding tolerances, to the extreme, largely because of the precision required to both setup and program the robot's movements, as well as a good understanding of material qualities that can withstand testing in an unconventional situation .



Robot undertaking digital rod bending fabrication

Source: Melonie Bayl-Smith

A similar challenge with student projects especially is the concept of the standard build against the custom build component. Even though there is an ease of “cutting” with digital fabrication, this does not necessarily translate such that the proposed component will work out as intended or be easy to build with as either a repeated component or in tandem with other elements in the design/build project.

On a related note, digital fabrication also casts new light onto the intersection of form discovery, spatial skills and material expression as they might be exercised and developed in the design/ build project. Issues of scalability are quickly highlighted in the robot fabrication processes, where the limitations of the robot's movements and pace can seem very slow due to the material property parameters fed into the robot, and that then require tweaking depending on the project for which these parameters are being provided.

8. DESIGN INTEGRATION

In referring to the Ostwald and Williams report, Recommendation 6 talks about the move away from core skills in the curriculum (such as Building Technology, documentation and other technical knowledge areas) towards the teaching of generic skills. This is a wasteful route for architecture to be headed down especially when the opportunities of design integration teaching and studios are specifically capable of aligning, combining and creating useful oppositions between generic skills and core skills. Further to this, when generic skills are given exercise by way of design integration projects they are made ever more purposeful and support the learning of core skills and knowledge bases. In support of this assertion, reviews of several institutions visited for the BuildAbility research project follow on below:

TU Delft

TU Delft has an enormous Faculty of Architecture, which encompasses five departments, being Architecture, Building Technology, Landscape Architecture, Urbanism, and Real Estate and Housing. To understand the scale of the faculty, at present there are around five hundred students in the first year of the undergraduate Architecture degree. It is worth noting here that the two most recent student cohorts at TU Delft will be the first students to complete their students with the fully implemented design-integrated studio and curriculum in the reworked Bachelor's program.



TU Delft studio Source: Melonie Bayl-Smith

Unlike the soaring entry scores required for Australian universities, TU Delft has no requirements for entry to the Bachelors degree program. Instead, the intensity of the curriculum and projects, along with the unrelenting application of high marking standards (e.g. a mark below 60% is considered a fail) are used to establish the expectations of the Faculty, as well as instigate natural attrition rates. This process is further enabled and measured by programming an intermediate assessment at week 4 or 5 of the semester, which may result in a halving of tutorial group numbers, but means that few students genuinely fail at the final presentation.

Whilst visiting TU Delft, full day design crits for the second semester, 1st year project were observed and reviewed across two consecutive days. This project was moderate in scale, had an unusual site (an island), and a provocative program and functional brief that included a cafe, cinema, and lookout with integration of a small ferry wharf. Students were required to submit four A1 panels describing the Design, Structural solution, Construction, and Sustainability considerations. In addition, they also submitted a design model at 1:50 (including prior iterations where relevant), a structural model at 1:50 and a 1:5 model of the “skin” system including window/glazing detail, and written reports. In their tutorial groups, the students then made verbal presentations to a panel of three critics – two tutors, and a specialist technical tutor from any of the three “technical” areas.



1st year student submission TU Delft Source: Melonie Bayl-Smith

On this note, most tutors in the Bachelors program are practicing architects, and practical experience is valued very highly. Of greater note is that they range in age from their late 20's through to late 60's, and some have tutored at TU Delft for the past 30 or so years. In discussion with these architects about why they decided to take time out of their practice and other activities to tutor, all of them saw tutoring as a long term commitment - as part of their role as a practising architect and an opportunity to pass on professional skills and knowledge.

With regards to the success and challenges of the design integration approach, there were a range of observations from the permanent academic staff as well as sessional tutors and students. There was certainly conviction about the capability of design integration curricula and their implementation to combat the problems inherent with the Dutch architectural culture of 'design practices' and 'documentation practices'. Whilst some felt that the pursuit of integration was sometimes to the detriment of developing design skills in the Bachelor's degree program, there was

confidence that this was comprehensively addressed in the Masters' program and that this was potentially a better place to take on more radical ideas of design and practise.



Architecture modeling studio, TU Delft Source: Melonie Bayl-Smith

TU Berlin

Attached to the TU Berlin is a hybrid architectural practice known as the Baupiloten, directed by Dr Susanne Hofmann, a practitioner and teacher at TU Berlin. The Baupiloten is one of two teams within her practice Susanne Hofmann Architekten: one team comprises graduates and registered architects, the other team comprises students presently studying at TU Berlin.



Kita Taka-Tuka-Land, 2005-07, Die Baupiloten Source: http://www.baupiloten.com/ger/projekte/taka/Main_taka.htm

The teams work both independently and together on integrated tasks, and this arrangement provides an interesting experiential research platform for understanding practise alongside the implementation of integrative design skills. Further, the proximity of the practice to the faculty (both physically and also by virtue of its pedagogical interests and connections) has meant that a long standing link is established between practise, the evolving curricula of TU Berlin and the activation of the students' skills, knowledge and experience. The hybrid practice structure also provides an opportunity for a rotating roster of students to participate in real-time projects that are infused with material and spatial research, and the experimentation that is customary for the projects undertaken by the Baupiloten and by Susanne Hofmann Architekten. Tangible evidence of the success of the Baupiloten is the extensive publishing of their projects as well as research papers, and interviews with Dr Hofmann on a variety of topics relating to architecture, architectural education and educational facilities.

Unitec Auckland

For the Head of School at Unitec Auckland, Assoc Prof Tony Van Raat, design integration is key to the culture and philosophy of the school. He also identifies that teaching within the school must be supported by a distinct engagement with the profession via practitioner-tutors, external teachers and adjunct roles. By way of this approach, the school is able to create meaningful connections to the professional and general community in which it resides.

It was observed, in conversation with various staff from Unitec, that a core part of the design integration philosophy at the school is that integrative thinking and learning depends heavily on time and skills, and these are factors over which the school cannot exercise ultimate control. Students must take initiative utilising the frameworks provided, including the design studio, to further their learning and immersion in architectural knowledge and practise.



Design/build pavilion, Unitec Auckland *Source: Melonie Bayl-Smith*

This integration approach is supported by design/build projects, individual technical subjects and the short term visiting lecturer program. By engaging with international guest lecturers on a short term

basis, ranging from six weeks to a full semester, the school is employing a flexible and variable approach to integrative learning. This approach is propelled by experimental studios, short term research projects, site specific studies, travelling studios and material investigations. From these different approaches and design forays, students learn to ask questions about conditions and context, providing a basis for introducing and developing integrative design thinking.

In a way, the end goal of this approach to design integration is to establish a creative working knowledge, so that reflective learning, discernment and an articulate architectural language is planted firmly within architecture students and graduates.



Unitec Auckland, student work *Source: Melonie Bayl-Smith*

Victoria University Wellington (VUW)

At VUW, the undergraduate construction curriculum is such that at present, in the 1st and 2nd year programs, the first semester consists of straightforward technical teaching in Construction and Structures, whilst the second semester is entitled “Design Integration”. In The 3rd and 4th year, design integration is a core part of many design studio projects, with construction teaching as a complement to this. The two part subject framework mentioned previously allows for the investigative reviews of materials, surfaces, junctions, joints, detailing, services, and amenity – and does so on the basis of the foundational learning undertaken in the previous semester. The opportunities to position the exploratory in counterpoint to standard practise also allows students the chance to explore the use and design of building elements in a controlled way and outside of the pressures of their design studios.



Structural models, 2nd and 3rd year architecture, VUW - Source: Melonie Bayl-Smith

In the “Design Integration” subject, the design programs employed become not only a vehicle for students to flex their design and construction muscles together, but also offer the prospect of developing other areas of knowledge and skill, such as typologies, history, theoretical propositions, sketching, CAD and modelling. This is partly enabled by the extensive use of process diaries along with a range of investigative and presentation techniques. Approaches and concepts such as adaptive reuse, forensic architecture and modularity have been utilised for the program bases for the Design Integration subject, allowing building technology and construction to be simultaneously edgy, vital and purposeful for the students.



Construction model, 3rd year Architecture, VUW - Source: Melonie Bayl-Smith

Daniels Faculty of Architecture, Landscape and Design, University of Toronto

Throughout both the Bachelor and Masters programs in architecture offered at Daniels, design integration is woven through the studio projects and subjects with both reflective and exploratory technical resolution being sought. As an example, the first year integration course is taught as a single subject, 'Introduction to Architecture', accompanied by the initial design studio 'Introductory Design', the description of which is below:

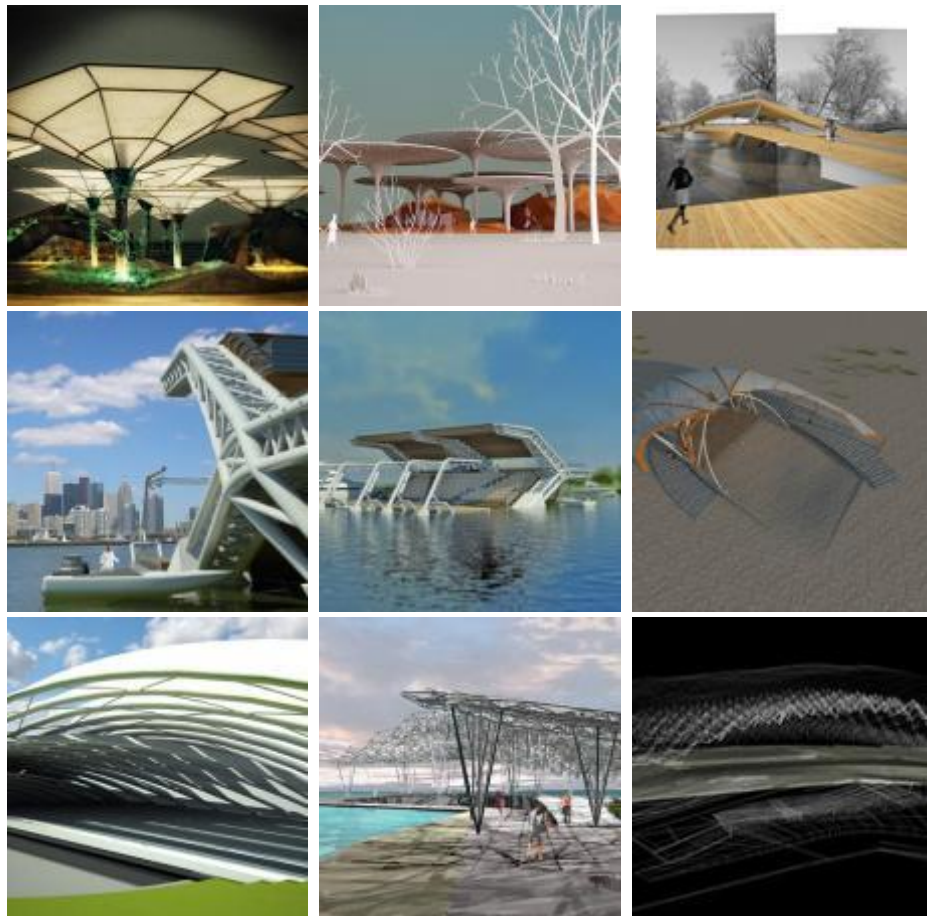
[This studio] serves as a laboratory and forum for the development of necessary critical and conceptualizing skills. Students develop an understanding of the phenomenology of basic elements of shelter and its implications for the design of constructed space and environments. Facility with the process of ideation is developed through exercises requiring analytical study, creative two- and three-dimensional composition and design of a building for a site situation and use program of limited complexity.

This description makes the design integration philosophy clear, and this intent is continued and supported by subjects in subsequent years of study, such as Architecture and Technology, Building Technology-Ecology, and Architecture in its Technological-Ecological Context. The description of this particular course demonstrates the depth and breadth to which integrative learning and teaching might aspire, which is included below:

This course examines modern architecture's contested relationship to questions of technology from the eighteenth century up to the present. This history is not presented as a triumphalist one of progress. Technology is understood in the course not simply as the increasingly more sophisticated materials, instruments, or techniques that became available to architecture in the last three centuries but also as a force that reconfigured architecture's ethical function by redrawing the boundaries between the natural and the man-made. Viewing architectural modernism through the lens of technology thus becomes an alternative way of understanding the role that architecture has played in the project of the Enlightenment. The course identifies thematic threads—ecological, tectonic, environmental, and digital—in architectural discourses since the eighteenth century but proceeds chronologically to weave these threads together. Weekly lectures are complemented with formal debates to be held in class every other week.

In speaking with David Lieberman and Ted Kesik from Daniels, it was interesting to note that in spite of the varied staff backgrounds, there was solid interest in supporting and maintaining integrative teaching and learning as the intent of the school's curriculum. It was observed that design integration teaching effectively assisted in removing the temptation for architecture to always be self-referential and self-focused. Having said this, design integration approaches allowed tectonic theory to act as a mode of teaching construction and building technologies.

In these conversations, it was also noted that there was still a place for instructional construction teaching, where the language of construction could be developed as a set of 'navigational skills' for architecture students in relation to design and making. This, however, should not be at the expense of exploratory construction teaching.



Dr David Lieberman Design Studio 5: Collaborative Structures Student work samples

Source: <http://www.daniels.utoronto.ca>

ETH

In interview with Prof Dr Philippe Block, who teaches Structures and is head of the Block Research Group at ETH Zurich, he identified the need for 1st and 2nd year architecture students to have a well rounded introduction to construction and structures that runs alongside and interconnects with their studies in history, theory and design.

Rather than dampen their enthusiasm or limit their thinking, the approach to teaching this material is to provide the basis for understanding the possibilities of exploratory design work as well as traditional construction. By undertaking design and technical exercises during tutorial time, students have the benefit of the tutor's expertise as well as small group interactions and peer to peer learning. This then assists to free up time for the students' design work and other assignments.

Alongside Structures is the teaching of Construction, with several Chairs of Architecture and Technology who are involved including Prof Andrea Deplazes, Prof Adam Caruso and Prof Annette Spiro.



Structures modeling assignment, student work. 1st year architecture ETH *Source: Melonie Bayl-Smith*



1:1 scale wall sections. 1st year architecture ETH *Source: Melonie Bayl-Smith*

Prof Spiro takes a construction studio in the 1st year program in which, for example, students produce 1:1 scale hand-drawn sections of full wall sections from roof through to foundations. At a more advanced level, Prof Caruso teaches a studio named “Integrated Discipline Construction” where in the context of the semester-long design projects, the reciprocity between design, construction and materiality is reinforced, a focus of which is the coherence of design and construction.

University of Bath

Design integration teaching is deeply embedded at the Department of Architecture and Civil Engineering at the University of Bath. This approach has been core to the philosophy, culture and curriculum of the school and its degree programs for the last three decades, including during Peter Smithson’s time at the university where he was known as a devoted and inspiring teacher. The Department employs a wide range of specialists in order to maintain and enhance its status in teaching and research, and engages actively with the profession by employing a large number of tutors who are practising architects and civil engineers. This is further supported by visiting academics who are engaged to advise and propel the teaching and research strategies of the school.

Some of the observations made by those staff interviewed for this project give a clue as to why the culture of this school remains innovative. Firstly, they liken technical knowledge as a series of doorways, and that teaching building technology is about bringing students to the threshold of each of these doorways, but not necessarily taking them across the threshold - students can find their way later. Secondly, it is generally considered that object making is a trap for students regardless of whether the school of architecture’s philosophy is driven by tectonics or by theory – and therefore solid technical teaching is recognised at not being an exhaustive solution to a delivering better solutions to design problems. Lastly, the iterative process is generally alien to engineers and this is a key cause of cultural difference between architects and engineers which the faculty seek to remove as a barrier in the students’ future professional lives.



Student work, 1st year architecture models for design/build project *Source: Melonie Bayl-Smith*

By running integrated design studios at various points throughout the program (including group design projects with Civil and Environmental engineering students), students are availed numerous

opportunities to look at typologies of construction and technologies, and to consider the logics behind processes for manufacturing, processing and building. In connection with these projects, students are encouraged to develop detailed structural models and utilise large scale building sections as a key assessment tool for the integrity of a design, rather than requiring endless plans and elevations. Having observed and participated in the studio review sessions for a 3rd year integrated design project whilst at the University of Bath, it is clear that by asking architecture students to collaborate with students who are studying specialist consultancies, there is a certain level of confidence and respect that enters into the architecture students' attitude and understanding of practise and professionalism.



Student work, 1st year architecture models for design/build project *Source: Melonie Bayl-Smith*



9. MATERIALS

Materials and their qualities, as well as their interactions in assemblies, lie at the core of building technology and its place in the design, execution and life of architecture. However whilst there is an enormous amount of information about materials, products and details at the fingertips of the present day student, more often than not the possibilities of this information are not able to be clearly discerned or utilised because of the lack of foundation knowledge students have about basic materials in the first place.

This scenario is further exacerbated by many current day students having grown up with the rise of planned obsolescence and consumer culture – where the ability to make and repair objects has become of little value in mainstream society. For those who have been in universities for some time, whether that be as academics, researchers or workshop managers, this kinaesthetic disconnect that is problematic with many students entering architecture studies today makes the teaching of construction, and materiality and assembly in particular, all the more difficult.

In those schools where ideas of making are embraced (and even more so those places where the making of ideas is equally embraced), it is then not uncommon to see both studios and research projects where material qualities and experimental assemblies are investigated with rigour and diversity.

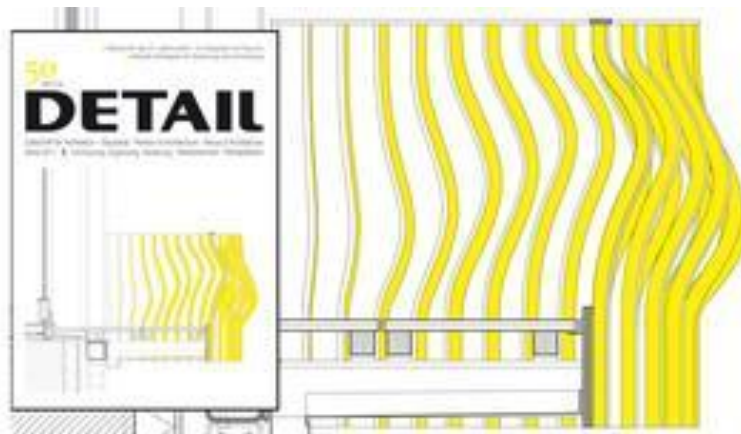
Cultures

Central to the livelihood of the materials and assembly culture in architecture is the German architectural magazine **DETAIL: Review of Architectural and Construction Details**. The magazine has an intensely loyal and substantial membership, and its issues are commonly utilised for reference in both practices and architecture schools across the world, partly due to the purposeful and contextual richness of each issue. Invariably, the magazine attracts some criticism in relation to the transferability of details across countries and climates. However, its Editor in Chief Christian Schittich noted in interview that whilst the usefulness of a specific detail might be removed because of local standards and building culture, a broad representation of material usage is important for growing knowledge of construction in an international sense, and also stimulating different ways of thinking about design. This is most obviously achieved by DETAIL in that each edition usually focuses on

either a specific material (e.g. Steel, Concrete), a particular set of assembly conditions (e.g. Facades, Interiors), or occasionally on a typology (e.g. Education buildings).

Interestingly, whilst the buildings featured in DETAIL must exhibit a balance of best practise and innovation, the most important element is the building's overall performance: aesthetically, functionally and technically. The focus is always on the details in relation to the whole building and therefore the contribution of both materiality and assembly are given equal priority in presenting the selected projects.

DETAIL also sees as its charter and intent is the promotion of a strong documentation culture in architectural practise, which taps into some of the major challenges being faced by the profession today, including BIM and less conventional procurement methods.



DETAIL magazine 2011 Source: http://www.detail.de/thema_additional-content-films-pictures_38_En.htm

Beyond the realm of detailing, it is pertinent to reflect back on the presentation of raw data and material samples to students within architectural programs, and how this information is connected to both the act of making, and the design propositions pursued in studio projects. Some universities choose to maintain a technical library within their faculties so as to provide students a tangible resource for understanding building elements. More potent, although far less common, are the rich and diverse holdings of architecture school material libraries – including those notable examples at **TU Munich** and **Harvard GSD**.

For example, TU Munich has a huge building materials sample library available to students and is highly visible in terms of its location and presentation to the public realm. At Harvard, whilst the library struggles with the accessibility of its physical location, being situated in the basement alongside the workshops, it nonetheless has established a local and online presence. The philosophy of the materials library at Harvard GSD is to have examples of experimental prototypes and samples from specific building projects, as well as standard material samples provided by manufacturers. This enables students to see materials “in flux” – as prototypes and material investigations – and not just as the finished product ready for construction.



Harvard GSD Materials Library Source: Melonie Bayl-Smith

A part pragmatic, part poetic exposition of materials, material language and material characteristics is a distinguishing feature of the teaching of Meredith Bowles, who coordinates the 3rd year Studio at **Cambridge University** and along with Tim Mitchell from Mitchell Taylor Workshop, is a leader of 'Studio in the Woods', a design/build educational programme aimed at giving architectural students and young architects an experience of building and making.



Studio in the Woods onsite build Source: <http://www.mitchelltaylorworkshop.co.uk/studio.asp>

In the 3rd year studio at Cambridge, a conceptual investigation has been developed to expand and nuance student thinking with regards to the richness of language and design opportunities that material understanding offers. The conceptual investigation, in the case of this particular studio, involved a process of ‘material mapping’ within the urban context for the project site. This mapping required the students to make experimental devices to record materiality. These devices became the means for exploring scale, material textures, composition, history, tectonic expression, collections of buildings, and layering in the urban fabric. A key purpose of this exploratory task is to foster both a micro level and macro level understanding of the urban and built environment. Such investigations also imbue a sense of the influence of site and the location of the tectonic within a specific site.



3rd year student work, urban and material investigations *Source: Melonie Bayl-Smith*

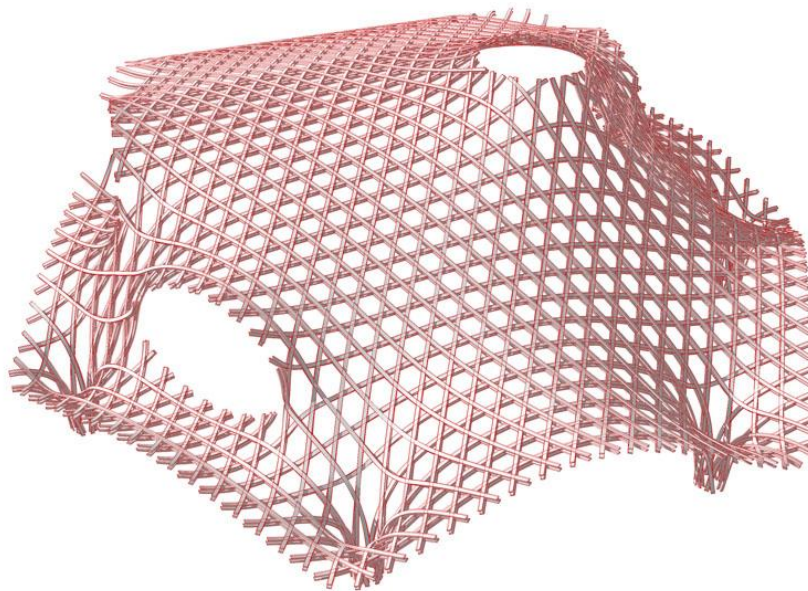
One of the tutors for the studio at the time of visiting was artist Tim Melville, and his most keen observation was that materiality is where the building touches the user with no voice – the passerby – and that materiality could not be ignored in the assembly, renewal and conservation of our urban spaces. Further to this point, this studio also proposes that materiality can address future issues, especially where form or program may not be able. By therefore simultaneously embracing the properties and poetry of materials, both this studio and the general approach of the curriculum assist in removing the ‘mythologies’ of building science and technologies.

Construction and Complexity

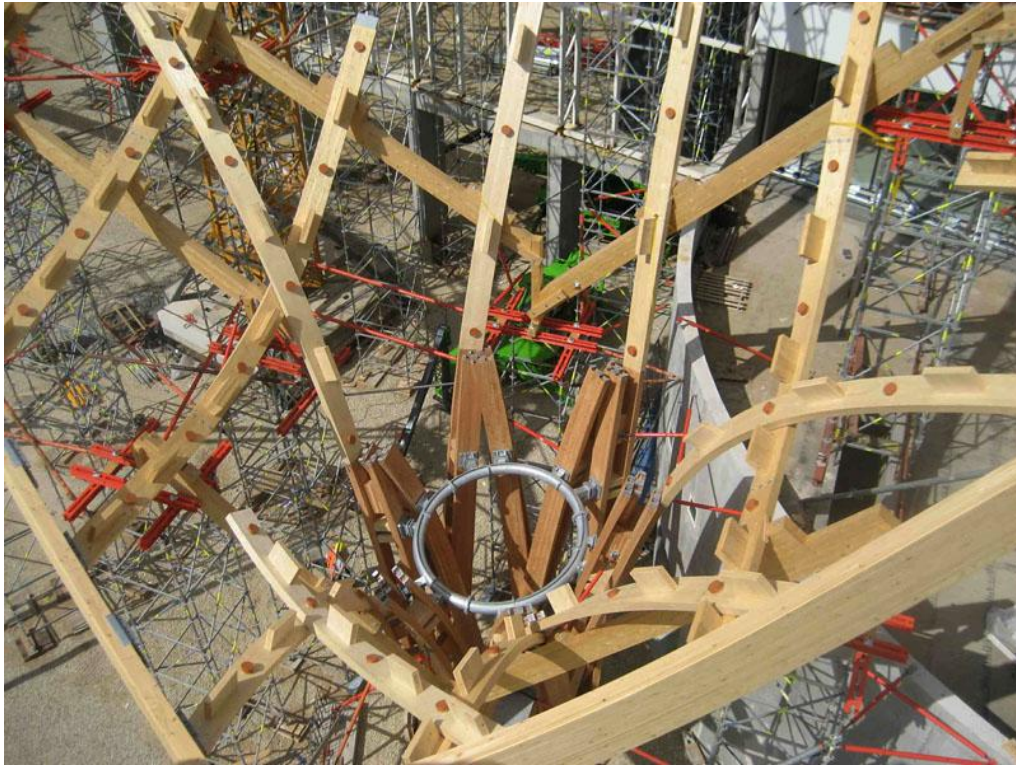
Situated at the nexus of construction and complexity in design are groups such as Design to Production (DtP), a multidisciplinary design and facilitation practice led by Fabian Scheurer at their

Zurich office. Identifying the multi-disciplinarity of DtP is particularly relevant as Prof Scheurer is a computer scientist, rather than an architect or structural engineer. His key interest, which is one of the main drivers for DtP, is in seeking to interface the abstract order of digital systems with the creative output and processes of design. Established in 2005, Design to Production are commissioned to undertake or support investigative stand-alone “research objects” for architectural projects, industry, exhibitions and the like, as well as being part of selected research projects at ETH Zurich across architecture, computer programming and structural engineering. DtP’s increasing presence in complex architectural projects worldwide highlights the potency and applicability of research alongside practise, as well as the challenges that face those architects and builders of complex geometries.

In speaking with Scheurer, it is clear that key to the problems of realising complex architectural forms is a deficiency in understanding the lack of scalability of materials. This failing can be readily drawn back to architectural education and an identified lack of interest in properly researching materials and their properties. Parallels to other design disciplines were also discussed in relation to this topic – for example, industrial design faculties would never remove technical components from teaching or curricula as many schools of architecture have done, as this would undermine the ability for construction thinking to become inherent in praxis and thereby naturally inform students’ design thinking. Further, given the ability of 3D modelling software to produce complex geometries and effectively “build anything” in the digital realm, Scheurer also believes that setting constraints and parameters is more important for student learning than ever before.



DtP digital model of the Centre Pompidou Metz (Shigeru Ban) Source: http://www.designtoproduction.ch/images/stories/projects/POM_slides/02_Girders.jpg



Construction of roof elements Centre Pompidou Metz (Shigeru Ban) Source:
http://www.designtoproduction.ch/images/stories/projects/POM_slides/09_Assembly.jpg

Interestingly, though Scheurer recognises that he is possibly a part of the “rise of the consultant”, a worldwide complaint about the architect’s territory being eroded by specialists, the flipside of this reality is that architects rely on these specialists and consultants to resolve those complexities in their designs for which they wish to avoid liability or committing resources. Whilst risk management is an element of all design practise, it has been observed that there has become, even at the most elite levels of architecture, a rather inappropriate reliance on the consultant to resolve design problems that ultimately impact on the aesthetic and functional execution of a building.



10. EMBEDDED PRACTICE AND RESEARCH

Observations made through this research project evidenced that embedded practice appears to go some way to diversifying staff profiles and employment opportunities within architectural schools. By virtue of this, embedded practice approaches also appear to provide the vehicle to address the delivery of teaching in core skill areas which are of concerns to the profession at large. Further, the multiple and diverse outcomes of research conducted by embedded practice have the potential to be understood by a wide section of the profession and indeed the community. These case studies will demonstrate the potency of embedded practice in relation to building technology teaching and research.

From the observations made during the visits, reviews and discussions undertaken for the BuildAbility research project, it has transpired that embedded practice models go some way to solving the issue of diversifying staff profiles within architecture schools. By virtue of this, embedded research also appears to provide the vehicle to address the delivery of teaching in core skill areas, such as the teaching of Building Technology, as is the focus of this research project. I have selected a group of architecture schools where embedded practice models are used as a vehicle for teaching and research, and particularly within the area of Construction, Structures and Fabrication.

TU Delft

At TU Delft I was able to witness the workings of an enormous architecture school – which presents its own challenges and opportunities. One of these opportunities is the capacity to engage with thought provoking practitioners, such as DUS who are based in Amsterdam. TU Delft have partnered with DUS to provide outlets for their materials-based testing, prototyping and design project research. Below are images of the Bucky Bar, a temporary structure built in Rotterdam early last year, and also other examples of projects that literally build on the experimental approaches which DUS utilise to focus their design and material research activities. On the back of this research and to enable the carrying out of the experimental projects, TU Delft also engage with DUS to lead studios, tutor and create design/build exercises for elective subjects.



TU Delft architecture studio *Source: Melonie Bayl-Smith*

Because of its size as an architecture school, TU Delft has been able to establish an array of higher-degree courses including vibrant research-oriented Masters, offered by faculty groups such as the Façade Research Group. Because of their diverse backgrounds, the members of this Group teach in various roles across the faculty, provide research opportunities and expertise to students and industry alike, engage in research projects with both academics in other institutions and with practitioners, and connect with the broader profession via exhibitions, lectures, and publications.

ILEK / TU Stuttgart

At TU Stuttgart there are long time practice and academy connections via ILEK, which basically translates as the Institute of Lightweight Design and Construction. This group was founded in 1964 by Frei Otto, and Werner Sobek, an architect/engineer, was a student of Otto's who assumed the directorship of ILEK when Otto retired in 1994. The building within which the research group lives was an experimental building exercise of Otto's, and this tradition of prototyping and modeling continues apace, evidenced by the contents of the ILEK office. Design build experimentation and building at different scales is key to the testing of new and novel structural opportunities and material concepts, and is a formal aspect of all research and investigations that take place at ILEK.

The offices of Sobek's practice are no different. The work of this group is characterised by the diverse architectural and engineering backgrounds of the staff – again, all of whom teach across the faculty in various capacities. Similarly to the work of the TU Delft Facades Research Group, ILEK have strong industry connections, their work is published and exhibited extensively, and they are presently conducting a number of research projects not only in conjunction with Sobek's own practice, but also with other external architectural practitioners and engineers alike.



ILEK building and aerated space frames *Source: Melonie Bayl-Smith*

ETH Zurich

The Department of Architecture at ETH Zurich, Switzerland, otherwise known as D-ARCH, has made a number of strategic appointments over the past decade or so. This has entailed appointing practitioners or academics with a strong practise /experimental background to create research nodes within the school. Each appointment has its own particularities, but what is immediately able to be observed is that these various individuals, partnerships and practices maintain and further develop their involvement with the architectural profession via the strong practise position they had prior to their appointment. Practise is strongly advocated, as a vehicle for research and demonstrating research outcomes as much as anything else. The practitioners reviewed in this report are Fabio Gramazio and Matthias Kohler and Philippe Block.

Gramazio and Kohler

Prior to being appointed to ETH, Gramazio and Kohler had been working in practise together for 5 years, with their appointment to D-ARCH as Assistant Professors of Architecture and Digital Fabrication in 2005. Their digital materiality research was already evident in their built projects and unbuilt propositions, and this has blossomed into an array of networks, relationships, research outcomes and further projects. Working from this base, Gramazio and Kohler are teaching undergraduate and graduate students in design studio and elective design/build projects and alongside this they are continuing this research to further foster their development as practitioners and the outcomes of their building projects.

They have established close links with parts of local and broader industry via the robot building research – and more interestingly, whilst the technical support and R&D outcomes from the robot maker are of obvious value, the relationships with the material manufacturers, especially the brick manufacturer, have become notably strong.

Below are a series of photos of one of their more recent current brick and robot design/build research projects, which has very recently been exhibited. In these photos the robot is making its first foray into building a wall with an opening and no lintel, purely from stacked bricks.



Digital brick fabrication, ETH Source: Melonie Bayl-Smith

In the following image is the basic brick element and in the rear ground you can see the prototypes of the coated foam sculptures laser cut from a single piece of foam that were decorating the main ETH quadrangle exhibited at the time of visiting ETH. These foam sculptures, and the stored past works clearly demonstrate that the research projects are focused on regularly producing outcomes for exhibition, publication. The research is unashamedly physical in its nature and it is presentable and readable by broader profession and student body alike.



ETH – brick used in Gramazio + Kohler fabrication research Source: Melonie Bayl-Smith

Block Research Group

Prior to being appointed to ETH, Philippe Block was based at MIT in the US, and had recently completed a PhD. Having already contributed to a number of design/build research ventures, publications and real time building projects, Philippe has established the Block Research Group at ETH, maintaining his practise and consultancy alongside continuing his work on vaulted structures and the application of masonry building techniques. Similarly to Gramazio and Kohler, and in fact in conjunction with several of their studios, Philippe Block is also working across the faculty in teaching undergraduate and graduate students structures via a range of methods, including, most importantly, integrated design exercises.



ETH / Cambridge joint masonry arch design/build studio – Prof Block *Source: Melonie Bayl-Smith*

The Block Research group are undertaking research into parametrics and older building technologies – here we see the prototype Stone Vault Pavilion, one of a number of investigative structures that examine materiality and design, old and new technologies, and structural principles for designing new projects and understanding old buildings.



Stone Vault Pavilion, testing models

Source: <http://block.arch.ethz.ch/projects/3>

Other projects include relationships between diverse entities such as MIT and the Ethiopian projects. This image here depicts construction activity on the Sustainable Urban Dwelling Unit (SUDU), a modular design proposal that looks at self-supporting vaulted masonry structures that utilise local materials and skills. What is attractive about this project is that it goes beyond “aid architecture” and instead partners with industry, students and community leaders in Ethiopia.



Ethiopian SUDU project: Block/Davis

Source: <http://block.arch.ethz.ch/projects/19>

The more abstracted experimental structural form investigations being undertaken by the group flow into the other more tangible and immediate activities of teaching, of design/build, of collaborations and of the African projects. Simply put, the research and the research outcomes do not remain in the realm of the specialist, but are instead immediately and deliberately dispersed to a broader audience.

By its very nature, embedded practice demonstrates that different technical or practical approaches to a design problem or to teaching might provide broadened avenues for further design investigation and for resolving the design issues. It also offers the potential for “research via play” - that hands-on experimentation can become immediately fostered via propositions, constructions and studio programs.

In summary, embedded practice also allows the academy to engage with those members of the profession who are interested in teaching, especially in technical or practical areas, who are less likely to be interested in being a full time academic, or in researching topics that are related to the actualization or more commonly understood “practise” of architecture.



ACADIA2010 exhibition “Evolutionary Means” digital fabrication propositions *Source: Melonie Bayl-Smith*



11. CONCLUSION AND RECOMMENDATIONS

In undertaking the BuildAbility research project, it is clear that the opportunities and challenges in teaching building technology subjects within architecture programs are shared by schools and professional bodies across Australasia and indeed internationally. In synthesising the information gathered during the research process, the following recommendations are made:

1. Allow architecture and engineering schools to invest in and create the capacity to deliver design integration learning opportunities by way of:

- Improving tertiary funding and committed, ongoing lobbying by the profession in support of the academy ;
- Establishing cooperative programs with the professions and building industry at large, including raising the profile of the ARC Linkage grant program within architecture schools;
- Improving, maintaining and raising the value of studio and workshop facilities within individual schools;
- Increasing the time dedicated within undergraduate curriculum and program to core subjects, primarily as construction, structures and fabrication are often combined into a single subject;
- Diversifying staffing profiles created by engaging with practitioners by way of different modes of teaching and research.

2. Support the establishment of an Australian and New Zealand base undergraduate building technologies curriculum that allows students to develop “ideas of making” alongside the “making of ideas”. Ideally such a curriculum would relate to emergent and traditional technologies and design thinking; the intersection of the programmatic with the tectonic using project typologies and topographies; and expected levels of competency for students and graduates. Within the Bachelor program particularly, such a curriculum would address the following elements via both integrated design projects and dedicated Building Technology teaching. Ideal conceptual drivers for the delivery of such a base curriculum might be as follows:

- **The elements of construction** – foundations, floors, vertical and horizontal enclosure, frames, joints and connections, openings, stairs and egress, roofs, etc
- **The design/ build project** as a design integration opportunity and as a compulsory component of architectural education

- **The 1:1 building experience** – coming up close to materials by way of visiting existing buildings, visiting buildings under construction investigation, handling samples and materials, and hands on building opportunities
- **The abstracted problem** – structure as program, material as program for design studios
- **The forensics of architecture and building** – measuring and drawing existing buildings, demolition processes, unpicking existing buildings, observing and understanding the remaking and attaching new work to existing
- **Standards and legal parameters** – standard building sizes and modules, building codes, building standards – and the influence of all of these standards on the articulation, materialisation, specification and execution of a design
- **The materiality of expression** – engendering an understanding of materials by introducing architectural language in an elemental and detail driven paradigm, encouraging curiosity and exploratory ideas in relation to materials, understanding where materials come from and how they are made
- **Services and systems** – the place, prioritisation and parameters of services and creating a basic understanding of their impact on the design, construction and life of a building
- **The environmental problem** – understanding sustainability through handling materials, learning the consequences and possibilities of active and passive systems
- **Structural strategies of form and space** – modelling and building structurally driven design problems to test materiality, form and spatial qualities
- **The case study** – historical precedents, diary of a construction project, hands on prototyping and design/build projects to test materiality, structures or parametric design
- **Drawing construction** – documentation and issues of representation, scale and communication the intentions of making

3. Revisit, rethink and realign desirable graduate attributes and professional competency standards by improved engagement between the key stakeholders to professions - academy, registration bodies, professional bodies, students, employers. It is proposed that this take place at the anticipated review of the AACA National Competency Standards for Architecture in 2013.

- Simplifying the competencies and allowing them to be integrated in approach, rather than separating design from the other competencies
- Investigating international internships models and propose the creation of a formal internship program for new graduates. The aim of such a program would be to provide a greater connection between practitioners, practices, the professional bodies and the academy. Such a program would also aim to greatly improve the inclusion and assimilation of graduates into the profession whilst acknowledging the range of established and alternative practise models in which graduates will likely participate.

4. Architectural schools to encourage opportunities to extend their building technology learning at Masters level in both the design studio program and electives - conversely, Bachelor degree programs must be rigorous and avoid the general or generic approach to undergraduate education that is presently pervading tertiary education in Australia. This might include:

- Compulsory construction component to major project or compulsory advanced construction integration subject in the Masters programme
- Offer more electives in construction/fabrication at the Masters programme level
- Technical teaching and learning opportunities either spread evenly across the entire five requisite years of study by way of a deep immersion design integration curriculum model, or alternately compacted into the Bachelor's program to engender a strong base knowledge that may allow greater freedoms for speculation and agendas in the Masters programme.

In conclusion, it remains that the teaching of Building Technologies depends on purpose, relevance, efficacy and integration. The language of tectonics needs to be communicated in an effective and concise manner, and the mythologies and mysteries of materials and details be removed so that the barriers that exist, real and imagined, can be taken away for the architecture student and graduate alike.



12. APPENDIX

Final itinerary and timeline for research project

March

European leg: Amsterdam - Interviews with architects, writers and sessional teaching staff

Delft – Interviews with architects, and academics, sessional teaching staff and students at TU Delft, observer at 1st year architecture design review crits

April

Stuttgart – Interviews with architects and engineers, and academics and researchers associated with TU Stuttgart (ILEK) and Stuttgart SAAD

Berlin – Interviews with academics and architects working at or directly associated with TU Berlin, including the long-running Mexico design/build studio

Munich – Interview with Editor in Chief of DETAIL magazine; review materials library at TU Munich

Zurich – Interviews with academics, practitioners and researchers at or associated with DARCH, ETH Zurich; observe and participate in lectures and design reviews with ETH architecture students

Sydney: attend Australian Institute of Architects 2010 National Conference “Extra-Ordinary”

May

Sydney: attend and document UTS design/build day with second year architecture and construction management students; conduct focus group interviews with architects and recent graduates

Newcastle: interviews and discussions with architects, current students and past staff from University of Newcastle

June

Canberra: BEMP conference – to review building, design integration and sustainability issues at the highest levels and how these are viewed across the broader profession and industry.

Newcastle: interviews with academics and teaching staff from University of Newcastle

July

Adelaide: interviews and discussions with academics, staff and architecture students from University of South Australia, review facilities, and view student work on exhibition; presentation of paper on Embedded Practice at Archivision 2010 conference

New Zealand: interviews with academics and teaching staff, from Unitec Auckland; interviews with academics and teaching staff, participate in design reviews with 2nd year architecture students from Victoria University Wellington; and interviews with practitioners and media in Auckland and Wellington.

August

Sydney: teaching 1st year Construction and Structural Synthesis at UTS, including reviews and discussions with students; Interviews with academics and practitioners associated with the University of Sydney

September

Sydney: teaching 1st year Construction and Structural Synthesis at UTS, including reviews and discussions with students

Newcastle: discussions with students from University of Newcastle including members of egresStudio, the student instigated and managed real-time build project currently under construction in the Hunter Valley

October

North America/UK leg: Toronto – interview academics and review student work at Daniels School of Architecture, University of Toronto

Michigan – interviews with academics, researchers, and teaching and workshop staff, review facilities, and participate as Guest Critic in design reviews for students from the M.Arch. program at University of Michigan, Ann Arbor MI

Boston: Harvard - interviews with academics, researchers, teaching and workshop staff and students from the M.Arch. program at the GSD, review facilities and materials library, and review student design/build work in progress and on exhibition

Boston: MIT - interviews with academics and workshop staff, review facilities and review student design/build work in progress and on exhibition

New York – attend the 2010 ACADIA conference “Life in:formation” with a focus on digital fabrication projects, held at the Cooper Union, and included viewing an exhibition of speculative digital works at the Pratt School of Architecture.

UK: London – interview with sessional staff from the Architectural Association (AA); focus group interview with final year students and recent graduates from University of East London and London Metropolitan University

UK: Bath – interviews with academics, researchers and teaching staff, review facilities, and participate in design reviews for students from the 3rd and 4th year programs

UK: Cambridge – interviews with academics, researchers and teaching staff; review facilities; observe joint design/build practical studio with ETH (in progress at time of visitation); and participate in design reviews for students from the 3rd year program

November

Sydney: UTS - teaching 1st year Construction and Structural Synthesis, including reviews and discussions with students; Guest critic in both 1st year design and 4th year elective studio, including design/build proposals and live installations

December

Melbourne: Interviews with academics, practitioners and staff at the Australian Institute of Architects, including full time and sessional staff from RMIT, Melbourne and Monash Universities, review student work available

Sydney: Interviews with academic/practitioners in both architecture and engineering at UNSW ; attend panel discussions and review student work at end of year exhibition for UTS



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University of Melbourne

Prof Paolo Tombesi

Monash University

Prof Shane Murray

University of Newcastle

Prof Michael Ostwald, Assoc Prof Anthony Williams, Annemarie Dosen, Willy Sher, Ramsey Awad

Bob Donaldson (past lecturer in Construction)

RMIT

Melanie Dodd, Stuart Harrison

University of Sydney

Dr Chris Smith

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Victoria University Wellington

Guy Marriage (Senior Lecturer), David Carleton (workshop manager)

2nd year Architecture students

Australia – architects, engineers, media and students

Shaun Carter (UTS/CarterWilliamson), Peter Sarlos (ARB), Penny Craswell (Artichoke), Rob Caulfield (ex Archicentre), Justine Clark (ex Architectural Media), Mandi Keighran (InDesign), Janet Renehan (SONA), Angus Kell (ex Archicentre), Tim Horton (IDC SA), Paul Berkemeier (UNSW/Paul Berkemeier Architect), Dr Flavia Marcello (Australian Institute of Architects), Chris Bosse (UTS/LAVA), Robert Beson (UTS), Harry Partridge (UNSW – engineering/Partridge Partners), David Springett (Australian Institute of Architects/Archicentre), Wayne Dickerson (JPW), Yvonne Haber, Rob Simpson, Chris Kennedy, Harry Sprintz, Clare Carter (Contemporary Architecture), Alex Chistiakoff, Steve Kennedy (Kennedy Associates), Kevin Clements (Cox), Adam Russell (UTS/DRAW), John de Manincor (UTS/DRAW), Stephen Lindsay (UTS/Lindsay and Dynan), Danielle Pinet, Samantha Donnelly, Joshua Morrin, Alasdair McPhee (SONA), Alysia Bennett (SONA/EMAGN), Samuel Jayseelan (SONA), Dominic Pelle (EMAGN), Anthony Balsamo (EMAGN), Joe Larkings (SONA), Sean McEntee (SONA)

New Zealand – architects and media

Craig Moller (Moller Architects), Christina Van Bohemen and Aaron Sills (Van Bohemen Sills Architects), Tim Melville (RTA Studio), Ron Waters (Accent Architecture), John Williams (TREND magazine), Errol Haarhoff (University of Auckland/NZIA)

Europe:

TU Delft - Faculty of Architecture

Assoc Prof Maarten Meijs (Dept. Building Technology), Tillman Klein (Dept. Building Technology), Nellie Schut (Chair, Design of Construction), Mark Pimlott (Senior Lecturer, Interiors)

Jim Van Oord (M.Arch. student)

Amsterdam

Rory Hyde (Architect / Critic, ex RMIT), James Webb (Architect, ex Claus + Kaan), Kirsten Gabriels (Architect), Hedwig Heinrich (DUS Architects)

Stuttgart

Prof Dr Patrick Teuffel (Engineer, lecturer TU Delft, ex TU Stuttgart ILEK)

Prof Tobias Wallisser (Architect, LAVA and Prorektor at Stuttgart State Academy of Art and Design)

Frank Heinlein and Roland Bechmann (Werner Sobek Studio)

Christian Bergmann (TU Stuttgart ILEK)

TU Berlin

Dr Ursula Hartig (Mexico-Berlin design/build coordinator and lecturer)

Dr Susanne Hofmann and Marlen Weiser (Susanna Hoffmann architects and Die Baupiloten)

Munich

Christian Schittich (Editor in Chief, DETAIL magazine)

Zurich

Prof Fabian Scheurer (director, Design to Production)

ETH Zurich

Dr Andrea Deplazes (Chair of Architecture and Technology), Prof Dr Philippe Block (Block Research Group and Chair of Building Structure), Prof Matthias Kohler (D-FAB, architect – Gramazio + Kohler), Nele Dechmann (Christ + Gantbein), 1st and 4th year Architecture students

North America:

University of Toronto, Daniels Faculty of Architecture, Landscape and Design

Dr Ted Kesik (Associate Professor - Building Science), Dr David Lieberman (Associate Professor - Architecture)

University of Michigan, A. Alfred Taubman College of Architecture and Urban Planning

Wesley McGee (Director of FABLab/ MatterDesign), Maciej Kaczynski (Researcher FABLab), David Pigram (FABlab / UTS / Supermanoeuvre), Asst Prof Kathy Velikov, Assoc Prof Geoff Thun, Asst Prof Robert Adams, Dr Steven Mankouche, Mark Krecic (Workshop manager), M.Arch. students

MIT, School of Architecture and Planning (SAP)

Assoc Prof John Fernandez, Chris Dewart (Workshop Manager), Assoc Prof Dr John Ochsendorf, Emily Lo, M.Arch. students

Harvard University - Graduate School of Design (GSD)

Assoc Prof Thomas Schroepfer, Rachel Vroman (GSD Fab Lab coordinator, Stephen Hickey - GSD Fab Lab director, Cam Willard - GSD Woodshop director, Liat Margolis (Materials Collection)

Ben Brady, Monica Earl (M.Arch. students)

UK:

University of Bath, Department of Architecture and Civil Engineering

Martin Gledhill (Teaching Fellow and Undergraduate Director of Studies), [Dyfed Griffiths](#) (Teaching Fellow and 3rd year coordinator), Rob Mitchell (Mitchell Taylor Workshop)

3rd year Architecture students, 4th year Architecture and Engineering students

University of Cambridge, Department of Architecture

Dr Michael Ramage, Dr Torwong Chenvidyakarn, Dr James Campbell

Meredith Bowles (Isaac Newton Teaching Fellow, 3rd year Coordinator/Studio in the Woods/Director, Mole Architects)

Tim Knowles (practicing artist and critic in the 3rd year Architecture program)

1st and 3rd year Architecture students

London

Manja Van de Worp (AA and ARUP), Hugo Mulder (ARUP)

Robert Pike, Chris Meyer, Dean Foskett

David Roberts (Hugh Broughton Architects) and Jill Roberts



14. BIBLIOGRAPHY

The BuildAbility research project involved a review of papers, articles, books and blog entries at various points during the undertaking of the research. A number of these were core to the establishment and structure of the research, whilst others provided secondary material and background for understanding the architectural agendas particularly supported by some schools of Architecture, particularly in the US.

Abruzzo, E. and Solomon, J.D (ed.) 2003, *306090 Architectural Journal, Teaching + Building: Beyond the Imagined*, Princeton Architectural Press, New York, New York, 2003

Angelil, M., 2003, *Inchoate: An Experiment In Architectural Education*, Darch GTA Publishers, Zurich, Switzerland

Architects Accreditation Council of Australia, 2008. *The National Competency Standards in Architecture*, 2nd Edition, pp 1-15

The Australian Learning and Teaching Council / Dr Susan Savage, 2011. *Draft Architecture Standards Statement – Consultation Paper*, Learning and Teaching Academic Standards Project, April 2011

Australian Government, 2010. *The Higher Education Base Funding Review Consultation Paper for the Review of Higher Education Based Funding*, Common Wealth Australia 2010, www.deewr.gov.au/BaseFundingReview

Bilow, M., Klein, T. and Knaack, U., 2008, *Imagine 02: Deflate-ables*, 010 Publishers, Rotterdam, Germany

Box, H. (ed.) 2007, *Think Like an Architect*, University of Texas Press, US

Bruhn, C. and Clark, J. (ed.). 2010, *Architecture Australia*, Vol. 99 No. 5 September/ October

Carpenter, W. J. 1997 *Learning By Building: Design and Construction in Architectural Education*, John Wiley and Sons Inc. US

Ching, F.D.K., 2001, *Building Construction Illustrated* (Third Edition), Wiley

Corser, R.(ed.), 2010, *Fabricating Architecture: Selected Readings in Digital Design and Manufacturing*, Princeton Architectural Press, New York, New York

- Deplazes, A. (ed.), 2006 *Constructing Architecture: Materials Processes Structures – A Handbook*, Birkhauser, Basel, Germany
- Deplazes, A. 2010, *Making Architecture*, Darch GTA Publishers, Zurich, Switzerland
- Gero, J.S. and Rosenman, M. (ed.), 2001. *CAADRIA2001*, Key Centre of Design Computing and Cognition, University of Sydney, pp 411-420
- Goetz, I. (ed.) , 2009, *Mexiko 2009: Praktikumsseminar*, TU Berlin
- Goetz, I. (ed.) , 2007, *Mexiko 2007: Praktikumsseminar*, TU Berlin
- Gramazio, F. and Kohler, M., 2006, *Winter Semester: Die Perforierte Wand* (Wahlfach und Diplomwahlfach), Lars Muller Publisheres, Switzerland
- Gramazio, F. and Kohler, M., 2007, *Digital Materiality in Architecture*, Lars Muller Publisheres, Switzerland
- Harman, K. and Bohemia, E., 2007, *Another Way of Thinking: Creativity AND Conformity*, paper presented at the Creativity or Conformity?: Building Cultures of Creativity in Higher Education, Cardiff, Wales, UK, 8-10 January
- Hungar, O. M. (ed.), 2008, *Mexiko: Praktikumsseminar*, TU Berlin
- Iwamoto, L., *Embodied Fabrication: Computer Aided Spacemaking*, Fabrication: Examining the Digital Practise of Architecture, ACADIA/AIA 2004 Conference, Nov 2004.
- Iwamoto, L., *Translations: Fabricating Space*, Journal of Architectural Education: Construction and Context, Vol. 58, Issue 1, September 2004, pp. 35-38.
- Iwamoto, L., Scott, C., *Phenomenal Surface*, Journal of Architectural Education: Surface, Vol. 57, Issue. 2 November 2003, pp. 22-28
- Iwamoto, L., 2009, *Digital Fabrications, Architectural and Material Techniques*, Princeton Architectural Press
- Ivarsson, J., 2010, *Developing the Construction Sight: Architectural Education and Technical Change*, Visual Communication, Sage Publications, Vol.9(2) <http://vcj.sagepub/content/9/2/171>
- Kolarevic, B., Klinger, K., 2008, *Manufacturing Material Effects: Rethinking Design and Making in Architecture*, Routledge (Taylor & Francis), London and New York
- Kolarevic, B., 2003, *Architecture in the Digital Age: Design and Manufacturing*, Spon Press (Taylor & Francis), London and New York
- Mackenzie, A. and Ward, M., 2010 *Architectural Review Australia*, Vol.115 June/ July
- Meijs, M. and Knaack, U., 2009, *Principles of Construction: Components and Connections*, Birkhauser, Basel, Germany

Ostwald, M.J. and William, A., 2008, *Understanding Architectural Education in Australasia: An Analysis of Architecture Schools, Programs, Academics and Students*, Australian Learning and Teaching Council, Australia, Vol. 1

Ostwald, M.J. and Williams, A., 2008 *Understanding Architectural Education in Australasia*, The Australian Learning and Teaching Council, Vol. 2: Results and Recommendations

SAW (Society of Architectural Workshop managers), *Survey of North American workshop facilities in schools of Architecture, Art and Design*, 2009 (web document)

Salhani, P. (ed.), 2010, *All theory, No Practise?: Current Perspectives on Architectural Education*, Architecture Bulletin November/ December

Schittich, C. (ed.), 2006, *Detail: Review of Architectural and Construction Details - Architects and Engineers*, English Ed. Vol. January/ February 2006

Sprecher, A., Yeshayahu, S., Lorenzo-Eiroa, P., 2010 *ACADIA2010 Life Information: Conference Proceedings*, ACADIA/Cooper Union/Pratt School of Architecture

Sobek, W. and Novak, B., 2008, *ILEK: Archi-Texture*, winter edition

Sobek, W. and Novak, B., 2008, *ILEK: Glass Studio*, summer edition

Wallis, L., Williams, T. and Ostwald, M., 2010. *The 'Studio' Conundrum: Making Sense of the Australian Experience in Architectural Education*, paper presented at Connected 2010 –the 2nd International Conference on Design Education, University of New South Wales, Australia, 28 June-1 July

Willkie, G. and Arden. S., 1984 *Building Your Own Home*, Weldon Publishing

Willhardt, R., 2007, *Chocolate On Thursdays: The young architects of Baupiloten translate users' dreams Into physical reality*, Viewpoint Vol. 8

Websites

<http://aaschool.ac.uk/> Architectural Association, School of Architecture

<http://www.acadia.org/acadia2010/> ACADIA 2010 conference

<http://www.bath.ac.uk/ace/> University of Bath, Department of Architecture and Civil Engineering

<http://www.baupiloten.com/> Die Baupiloten

http://www.planen-bauen-umwelt.tu-berlin.de/menue/fakultaet_vi/ TU Berlin Faculty of Built Environment

<http://block.arch.ethz.ch/> Prof Philippe Block

<http://www.arct.cam.ac.uk/Arct/Home.aspx> University of Cambridge, Department of Architecture

<http://www.arch.ethz.ch/darch/index.php?lang=en> D-ARCH / ETH Zurich

<http://www.solardecathlon.tu-darmstadt.de/home/home.de.jsp> TU Darmstadt Solar Decathlon site

<http://www.bk.tudelft.nl/> TU Delft Faculty of Architecture

http://www.deplazes.arch.ethz.ch/dplz_site/index.php Prof Andrea Deplazes

<http://www.designtoproduction.com/> Design to Production

<http://www.dusarchitects.com/>

<http://www.uel.ac.uk/ava/> University of East London, School of Architecture and the Visual Arts

<http://www.gramaziokohler.com/> Gramazio and Kohler

<http://www.gsd.harvard.edu/> Harvard Graduate School of Design

<http://www.uni-stuttgart.de/ilek/> ILEK at TU Stuttgart

<http://www.abp.unimelb.edu.au/> University of Melbourne, Faculty of Architecture, Building and Planning

<http://taubmancollege.umich.edu> University of Michigan – Taubman College

<http://sap.mit.edu/> MIT School of Architecture and Planning

<http://www.artdes.monash.edu.au/> Monash University Faculty of Art and Design

<http://www.ar.tum.de/> TU Muenchen Faculty of Architecture

<http://www.newcastle.edu.au/school/arbe/> University of Newcastle Australia, School of Architecture and Built Environment

<http://www.fbe.unsw.edu.au/> UNSW Faculty of the Built Environment

<http://www.sial.rmit.edu.au/> RMIT - Spatial Information Architecture Laboratory

<http://www.wernersobek.com/> Werner Sobek Studio

<http://www.solardecathlon.gov/index.html> US Dept of Energy Solar Decathlon

http://www.unisa.edu.au/artarchitecturedesign/?utm_source=schools&utm_medium=hp&utm_content=aad&utm_campaign=eass-improvement University of South Australia, School of Art, Architecture and Design

<http://www.abk-stuttgart.de/english.php> Stuttgart State Academy of Art and Design

<http://sydney.edu.au/architecture/> University of Sydney, Faculty of Architecture, Design and Planning

<http://fcms.its.utas.edu.au/scieng/arch/> University of Tasmania, School of Architecture and Design

<http://www.daniels.utoronto.ca> University of Toronto Daniels School of Architecture

<http://www.utsarchitecture.net/> University of Technology School of Architecture

<http://www.unitec.ac.nz/>

<http://www.victoria.ac.nz/fad/> Victoria University Wellington, Faculty of Architecture and Design

www.firstlighthouse.ac.nz Victoria University Wellington Solar Decathlon entry “Firstlight” site



UTS Doghouse design/build studio 2nd yr Architecture *Source: Melonie Bayl-Smith*

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