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BUILDING BRIDGES BETWEEN ARCHITECTURE AND ENGINEERING - TIMBER EDUCATION AT THE UNIVERSITY OF QUEENSLAND

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ABSTRACT: The University of Queensland (UQ) is one of few universities in Australia who offer a dedicated structural timber engineering course. For several years, this course has been taught in parallel with an architecture design studio. In an interdisciplinary group project, teams of architecture and engineering students design timber bridges at various locations across Southeast Queensland. They learn about a range of topics, such as timber as structural material, timber durability, Indigenous stakeholder engagement, and forest stewardship, with expert guidance from industry professionals. Through hands-on prototyping and problem-based learning, students develop both technical proficiency and practical interdisciplinary skills as future design professionals.

KEYWORDS: timber education, architecture, engineering, interdisciplinary teaching, project-based learning

1 – INTRODUCTION

Engineers Australia Stage 1 competency for professional engineers defines a key requirement to be able to interact “effectively with other disciplines, professions and people” [1]. Likewise, Communication is one of three core professional capabilities outlined in the National Standard of Competency for Architects [2]. To foster these skills, in 2019, academics from the University of Queensland’s (UQ) School of Civil Engineering and School of Architecture, Design and Planning introduced a collaborative teaching approach between a Master's of Architecture design course (ARCH7015) and a 4th year Bachelor of Civil Engineering course on structural timber engineering (CIVL4334).

This paper describes an exemplar of interdisciplinary teaching using project-based learning at UQ in the context of timber construction education. The teaching approach and methodology, design of teaching activities and the considerations around the project-based learning are described. Special focus is devoted to decolonising curricula and ways how non-Indigenous academic staff can teach aspiring professional architects and engineers to respectfully engage with Indigenous knowledges and Traditional Owners.

Finally, the paper aims to start a conversation how academics can help university students develop skills to communicate and collaborate effectively with other disciplines within the fields of engineering, architecture, and construction.

2 – BACKGROUND

After some preliminary discussions between the Course Coordinators, project-based learning in interdisciplinary teams was identified as the most effective format to engage the student cohorts in a meaningful collaboration. This has the benefit that both courses can provide tailored briefs and marking criteria relevant to their respective disciplines. It also allows more flexibility in teaching activity schedules as intensive studio-based collaborative work typically starts in week 6 of a 13-week semester.

In the first five weeks, civil engineering students complete content learning through online modules, lectures, and tutorials, while architecture students develop conceptual design proposals. Students are asked to self-select into diverse teams within both architecture and engineering

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cohorts; all students meet for the first time during a field trip to the project site, typically organised during the second week of semester. This initial 'meet and greet' during a full-day trip is intended to help with interdisciplinary team matching and group dynamics.

For the Master of Architecture cohort, in addition to lectures and tutorials, students work in groups in the early stages of the project conducting research on the cultural history of their site and analysing timber structure precedents. They also learn through material engagement by participating in a series of iterative prototyping and model making exercises held in a construction workshop. Within a month each group is ready to present a masterplan for the site and a conceptual design proposal for a large timber structure. Architecture teams then pitch their designs to civil engineering peers in week 5, and engineering teams vote on their favourite designs — reversing the typical professional dynamic where structural engineers are engaged by architecture firms.

Once architecture and engineering teams are matched, the interdisciplinary teams complete the architectural and structural design of a timber structure over the course of a 6-week project. The brief and site location vary each year, and students are expected to engage with historical precedents (**Error! Reference source not found.**).

Figure 1. Decommissioned rail bridge on the Brisbane Valley Rail Trail (left) and footbridge at Narda Lagoon (right, photo Edgar Stubbersfield).

Over the years, projects have included futuristic timber mega-structures, timber foot and cycle bridges for the Brisbane Valley Rail Trail and Laidley Narda Lagoon, as well as timber fire-watch towers.

The methodology involves research by design, studio-based techniques, and experimentation with timber elements, underpinned by detailed studies of timber construction. The interdisciplinary groups collaborate in weekly joint studio sessions and engage in hands-on learning activities, such as a model bridge building competition, to playfully critique the structural feasibility of their designs (Figure 3 and 3).

The course includes several joint guest lectures on topics such as forest stewardship (delivered by Responsible Wood), Indigenous stakeholder engagement, and timber footbridge design criteria. Industry professionals not only deliver guest lectures but also mentor student teams, guiding them in technical queries and interdisciplinary challenges.

Furthermore, academic colleagues and industry guests are invited as 'judges' of the final interdisciplinary designs: During 'elevator pitch' presentations, the student teams' designs are judged by both engineer and architect 'clients' on aesthetics, innovation, and creativity. The designs must consider their surroundings, connection to place and peoples (incl. Traditional Owners), and broader societal benefit and impact. This includes selection of locally available timber species and deliberations of using durable native hardwoods versus using treated plantation softwoods.

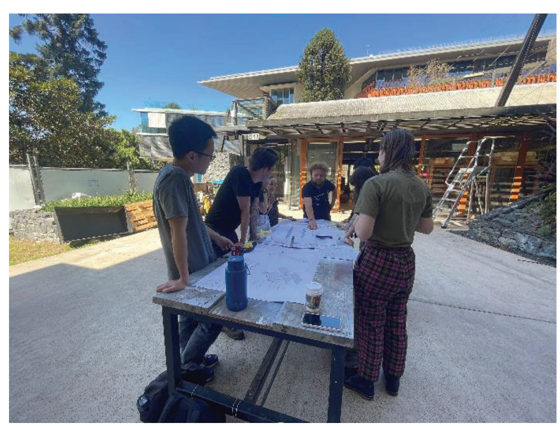

Figure 2. Group discusses their bridge design and model making.

Figure 3. Collaborative hand-on learning. Students discuss design (left), create members (centre), and work on bridge testing (right).

The following sections highlight two focus areas of the joint teaching pedagogy: 1) Efforts taken to decolonise curricula and respectfully embed Indigenous knowledges in teaching and learning, and 2) inclusion of industry guests as lecturers, mentors, and judges to draw from professional best-practice.

2.1 DECOLONISING CURRICULA

The teaching staff are conscious that none of the academics involved in the course delivery are Aboriginal or Torres Strait Islander people. This is in part owed to a low number of Indigenous academic staff members in the Faculty and limited teaching budgets that have so far not allowed to pay Indigenous knowledge holders and Traditional Owners to deliver guest lectures. Learning about Country, significance of place, and site-specific Indigenous history and culture is central to the course and part of a broader shift in academia to be more inclusive of First Nations knowledges. Students are reminded that the act of designing structures and architectures did not start with the arrival of colonial settlers but was preceded by makers from one of the oldest continuous cultures in the world.

Students learn about forest stewardship and responsible use of Australia's native and plantation timber resources. One of the architecture teaching staff specialise in cultural history. Students learn of the long standing and ongoing stewardship of indigenous trees and forests by Aboriginal people in Southeast Queensland. It is emphasised that current forest management and fire mitigation strategies are based on Indigenous knowledges and practices; Indigenous peoples have actively managed the continent's forests for millennia.

The course reiterates the growing acceptance for the need to engage with First Nations stakeholders and Indigenous knowledges supported by an increasing number of resources to help project leaders navigate this process. Integrating Indigenous art and artists into projects has historically been one way of increasing Indigenous engagement in a project; a good starting point is Janke et al.'s *Protocols for using First Nations Cultural and Intellectual Property in the Arts* [3]. Furthermore, Indigenous placenames are often adopted in naming of new infrastructure projects. A good resource in the context of Brisbane is Kane et al.'s *Aboriginal Places of Inner Brisbane* [4]. However, neither practice replaces meaningful consultation, engagement, and co-design.

Looking more specifically at architectural, engineering, landscape and urban design projects that have incorporated Indigenous knowledges we find that some are uniquely associated with specific Countries, while other incorporate Indigenous perspectives. Several projects have received accolades in awards programs, yet not all have achieved positive feedback from Indigenous stakeholders and contributors.

A great UQ resource aimed at achieving a clear idea of what meaningful engagement and outcomes are from Indigenous perspectives is *Campuses on Countries: Aboriginal and Torres Strait Islander Design Framework at the University of Queensland* which was developed by UQ academics and released by the School of Architecture, Design and Planning in 2021 [5]. In the creation of the Design Framework, an iterative consultation process was used to ensure UQ's Indigenous leaders, staff, students, alumni and community were central to the direction and implementation of the Design Framework.

The Design Framework is a guide aimed at embedding indigenous knowledges into built environments and better recognising, including and celebrating deep connections to places. It presents six key Aboriginal and Torres Strait Islander Design Principles:

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- First caring of Country
- Shared respect, shared meaning, shared knowledge
- Deep listening
- Embedded voices
- Celebrating excellence
- Exploring Storylines

These Design Principles are mapped to eight exemplar design criteria that are representative of a common design process.

The Design Framework also provides advice on how to embed Indigenous design principles into the typical stages of a Design project. The Design Framework and its design methodology are shared with students showing them large scale engineering and architecture projects that demonstrate best practice examples of meaningful engagement with First Nations communities and Indigenous knowledges. Students are also provided with a detailed cultural history of their site, with a focus on forestry stewardship from both an Aboriginal and post settlement perspective.

2.2 INDUSTRY GUEST LECTURES

Guest lecturers and project Q&A with industry professionals form an essential part of the engineering cohort course delivery. Guest speakers and topics have included connection design with Dr Jon Shanks from TimberEd, timber bridge design with Prof Robert Jockwer from TU Dresden, timber bridge durability Dr Dan Tingley from Wood Research and Development, mass timber design with Sameed Khan from TTW, project and team management with Joseph Thiang and Julia Cepon from Arup, pedestrian footbridge design with Stuart Rothwell from Transport and Main Roads (TMR), forest stewardship with Simon Dorris and Matt de Jonge from Responsible Wood, among others.

Guest lectures are delivered both online and in-person and students have the opportunity to ask project specific questions. Industry guests also give feedback during the engineering students' project progress presentation and act as judges during the final project presentation, which is also assessed by peers.

3 – PROJECT DESCRIPTION

3.1 CIVIL ENGINEERING BRIEF

Each year, CIVL4334 students are asked to collaboratively design a timber foot- and bicycle-bridge for a site in Queensland in an iterative process with their architecture team. In 2024, the site was the Narda Lagoon in Laidley, and in 2023, the site location was on the Brisbane Valley Rail Trail. The final design is assessed by a jury of professional engineers and architects on aesthetics, innovation, and creativity. The students are asked to consider the surroundings of the bridge, connection to place and peoples (incl. Traditional Owners), and broader societal benefit and impact. The following is an excerpt from the 2024 engineering design brief:

All main structural elements must be made of timber, except for abutments, and cables in suspension or cable stayed bridges. Students must use locally sourced timber species and materials and detail a durability strategy and maintenance plan.

The bridge needs to satisfy all site requirements, a minimum clear width of 3.6 m, and enough clear height that an emergency vehicle (ambulance, 1.5 t) can travel across the bridge. The design must satisfy all relevant load cases given in the AS 5100 series and meet criteria set out in AS 1720.1 and AS 5100 (Part 9: Timber).

Durability measures to protect against decay, insect attack and to some extent fire events need to be specified. Importantly, the timber structure must be detailed for moisture and related shrinkage and swelling: rain from above and the sides, groundwater, water flowing beneath, and flooding. Best practice timber detailing should ensure that softwood timbers are not in direct contact with the ground and are also adequately treated and/or detailed. Decisions to use naturally durable hardwoods need to be justified and resource availability needs to be considered. Connections need to be detailed correctly so not to trap water inside joints. A maintenance plan and inspection schedule need to be provided.

The students are instructed to use Australian Standards for member design which are deemed-to-satisfy, but their design must include at least one performance solution for connection design, using manufacturer information, an international design standard, such as Eurocode 5, or scientific publications.

Students may use any publicly available source to obtain site information, such as Nearmap, Google Maps, government and council websites, publicly accessible tender documents, etc. and all sources must be referenced accordingly.

In addition to the structural report, students are asked to create a team charter and provide a logbook detailing how they work as a team, collaborate with architects, and engage with industry mentors. They are asked to log their hours and document their iterative design. The logbook also contains meeting minutes and task allocations to effectively manage potential conflict within the team. The logbook represents 25% of the project mark.

3.2 ARCHITECTURE BRIEF

In ARCH7015 Generative Structures run in 2024, students investigated the design of an equestrian centre with ambitiously spanning public arenas, accompanying stables and a timber pedestrian bridge. Prototyping and model making were an integrated part of the design process. The project looked at best practice timber construction methodologies and how they may be applied to public arenas, agricultural buildings and timber infrastructure. Over the semester, students established a critical position regarding the cultural and historical role of the sustainable management of forest resources and design a suite of landscape interventions and novel structures.

3.3 FIELD TRIP

On the field trip the architecture and engineering students visited the site where an existing timber bridge was studied and measured drawings were prepared for later reference and interrogation of design details (Figure 4). The Architecture students then went to visit an existing large span equestrian shed and supporting structures in a nearby town before reconnecting with the engineering student for lunch and then a visit to a local History Museum where volunteers demonstrated traditional timber joinery, tools and vernacular architectures.

Figure 4. Field trip of engineering and architecture cohorts to bridge site at Narda Lagoon in Laidley.

3.4 DESIGN PROCESS

Over 6 weeks of the semester, students worked in their collaborative teams iteratively to develop the bridge design both in terms of the optimal structural form as well as detailed design of the connections. The design process also included rapid design build exercises where students had to build a scale physical model of their bridge using only a limited amount and limited type of material.

In these exercises students were forced to think carefully about how to use the materials effectively and to think about the performance of the model connections, even if simply glued or taped. The level of similitude between the model and the real design, whilst only approximate,

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nevertheless gave students physical feedback about how the structural form behaved under load (Figure 3). These intensive exercises proved to be very valuable for honing the collaborative group's ability to think quickly and to work as a team, and it was clear that those who were able to communicate effectively were able to both complete the task and gain a level of personal satisfaction through the process.

In the final design development of the project, students were required to design the detailed connections of the structure (Figure 5). This proved to be a fruitful collaborative exercise, in which engineering students had the particular knowledge to understand the performance requirements of the connection and the quantities of bolts, thicknesses of plates and offsets from the edges of timber members. In collaboration with the architecture students the teams were able to then consider how these could be refined visually to be carefully concealed within the depth of the timber members, or for example to have shaped profiles of the plate to enhance the visual appeal. They could also be modelled in three dimensions by the architecture students to show the appearance in a three-dimensional visualisation.

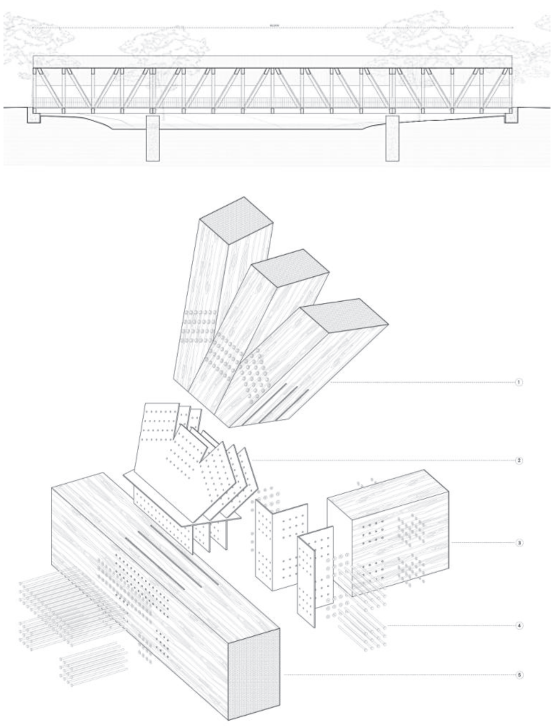

Figure 4. Elevation view of bridge and isometric view of connection detail - Oliver Cooper White, William Johnson, Yarden Lavy, Tim Window

4 –OUTCOMES AND FEEDBACK

Of the seven teams that produced designs, several of the projects were of an excellent standard and the majority of a very good standard (Figure 5). In addition to the bridge design, architecture students also took on part of their own project to develop individually and draw upon the experience that they had gained via working with the engineering students. In some of the exemplary projects it was possible to see learnings taken from the collaborative bridge design applied directly to other parts of the architecture students' own projects, which can ben be seen in Figure 6.

Figure 6. Visualisation of arena roof structure, and prototype of typical timber structural bay at 1:5 scale. Mubashshira Alam

Student feedback has been positive throughout, and several students have been awarded the Responsible Wood Prize based on their design. Furthermore, several

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graduates were inspired to pursue professional careers in timber in both research and industry.

The feedback from industry has also been positive which is reflected in industry guest speakers volunteering their time for several years in a row and going above and beyond in the mentoring of student teams. The project is frequently named as a highlight in students' course evaluation and both course and teaching staff have received outstanding evaluations despite the challenging nature of the project and course.

The successful collaboration has been showcased at Faculty and University Teaching and Learning weeks, as well as the WoodSolutions Industry Educator Workshop.

5 – CONCLUSIONS

The collaborative teaching initiative between Architecture and Civil Engineering cohorts at the University of Queensland has proven to be wholly successful, evidenced both in terms of the project outcomes, but also in the development of a meaningful collaborative experience for the students where they learn how to work together as two complementary but quite distinct disciplines. Of particular value was the breaking down of stereotypes that each discipline has of the other. Architecture students often come with a pre-existing belief that engineering students are rigid and do not think laterally, whilst architecture students are perceived by the engineering students to be wilful and unrealistic in their ambitious concepts. It was rewarding as an educator team to witness how these preconceptions change through the course of the semester as students learn to work together and reach informed collective decisions for the better of the project.

6 – ACKNOWLEDGEMENTS

Ted Stubbersfield is gratefully acknowledged for providing time and resources to support the Field Trip and teaching activities. Industry guests and lecturers are thanked for their continued involvement in the course.

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