Advancing Sustainable Wood Design and Technologies through Interdisciplinary Collaboration

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The use of wood in buildings is an age-old craft, but recent proliferation of innovative wood-derived materials such as mass timber in commercial, institutional, industrial, and residential building signal the need for an education that expands upon these technological shifts. Academia and industry are proactively developing new curricula to address this challenge. This paper describes a wood design studio taught in combination with a seminar course run prior to the Fall 2020 launch of a new Master of Design in Integrated Wood Design at Fay Jones School of Architecture and Design at the University of Arkansas, located in a state that is 60 percent forested. This post-professional degree is part of a long-term investment to meet future needs of the wood industry in Arkansas and the nation.

The studio–seminar clusters explored the nexus between mass timber and the built environment. These courses brought together teams of students from the departments of architecture, interior design, and civil engineering, and challenged them to examine the design potential of presenting wood and mass timber with the respect and legitimacy they deserve, to the extent of rivaling other materials like concrete or steel. This paper will first provide a discussion of the interdisciplinary collaboration, followed by the design method applied to mass timber.

The pedagogy of the studio rests on collaborative interdisciplinary teaching and learning between faculty, faculty and students, and students. The design method applied in these courses does not follow a typical process, simply to allow students to remain focused on working with wood to inform the making of space. Rather than starting with the site, programming, massing, and so on, the process is reversed, beginning with the small—the detail connection—culminating into the large—the building.

> [The material itself, stone or wood, does not interest me as such. It is a means; it is not an end. You do not make sculpture because you like wood. That is absurd. You make sculpture because the wood allows you to express something that another material does not allow you to.]
>
> —Louise Bourgeois

INTERDISCIPLINARY COLLABORATION

Lev Vygotsky, a Russian teacher and psychologist, is credited with theorizing we learn through interactions with our peers and teachers.[1] Social learning theory explains how people learn in different social contexts and how creating a more active learning community can positively impact a learner's ability and help meet individual learner's goals.[2]

In an interdisciplinary approach, faculty and students of different disciplines come together and students learn by connecting ideas and concepts across disciplinary boundaries, thus broadening the learning experience. Interdisciplinary collaboration expands on integrated knowledge through intentional and necessary coordination that goes beyond simply mixing approaches. Examples of this can be seen in "big science" initiatives such as nuclear development, where scientists from various fields came together and created new knowledge and innovations. In the design and construction fields, interdisciplinary collaboration has been gaining popularity.

The approach adopted in this studio was sequenced to merge disciplinary input at key moments of the process. Relevant interdisciplinary design education necessarily rests, first and foremost, on the genuine will of faculty and students from different disciplines to work together in ways that enhance learning about cross-cutting issues of timber design. For far too long, design education was conceived in silos, whereby students in architecture learn about form making, structures, and enclosure while students in interior design programs learn about the exigencies of interior spaces, and likewise for

landscape architecture and civil engineering students. Students may complete entire curriculums without one synergetic engagement with another discipline. Future graduates will immediately confront the reality of collaboration during their professional career, it is crucial they be exposed to and prepared for such a challenge during their education.

Indeed, design programs should have close working relationships within the university, particularly where fields overlap, and interdisciplinary learning is beneficial for faculty and students. Nevertheless, some degree of autonomy between separate fields ought to remain, allowing interdisciplinary collaborations to be made from a position of absolute strength in individual departments.

INTERDISCIPLINARY STUDIO AND SEMINAR INSTRUCTION MODEL

Interdisciplinary work is the "mindful involvement and integration of several academic disciplines and methods to study a central problem or project."[3] Building an effective decision-making capacity to address progressively complex design problems demands the collective intelligence that emerges from collaboration among individuals with diverse disciplinary backgrounds. Research indicates clear advantages to literacy across disciplines. According to Zollman et al.,[4] learning within the classroom should be a "meta-discipline," in which curricular areas are integrated to promote analysis and deepen understanding. Interdisciplinary collaboration propels students to deep learning, involving underlying conceptual ideas and relationships, as opposed to surface learning, which is often superficial, relying on memorization.[5] Deep learning requires the ability to employ internalized ideas of learning, to be less dependent on authority, and have confidence in what one thinks and does.[6] Implementing this philosophy requires a holistic view and an understanding of a host of issues beyond the borders of existing institutional and educational entities. Successful collaboration requires professionals who have the skills to engage in effective interdisciplinary work.

The aims of this interdisciplinary studio were to explore opportunities and obstacles present in learning through collaborative design between architecture, interior design, and civil engineering students; to acquaint students from one discipline with the thought process of peers from other disciplines; and to examine the impact of various collaborative strategies on improving the formative design process and outcomes.

Although not all integrative learning is interdisciplinary, all interdisciplinary knowledge is integrative. The interdisciplinary collaboration we undertook required integrating knowledge; crossing boundaries between and among the disciplines of architecture, interior design and civil engineering; and utilizing creativity and innovation. In the project-based approach, learning was planned around research, and design investigations; sketching, drawing and model making iteration, explanation, and then resolution of a specific challenge related to wood material culture imagination and its tectonic expression.[7] Students learned experientially as they worked through wicked problems and complex situations that do not have single correct answers. In collaborative groups they identified what they needed to learn in order to solve a problem.

BACKGROUND AND MOTIVATION

In the face of new and shifting demands for sustainable practices in industry and the world of design, wood is regaining popularity as a biodegradable and renewable material. In North America, 95 percent of single homes are built with this material, yet challenges remain to make wood viable, accessible, and attractive for all building types. The social calls for minimal or zero carbon footprint buildings are reshaping the attitude of the designer, who now carries the crucial responsibility for environmental consideration. In her book *Mass Timber Design and Research*, Susan Jones, FAIA, AtelierJones, articulates a clear analysis of the environmental challenges to the forest and to carbon emission in the Pacific Northwest.[8] Susan Jones, Thomas Robinson, AIA, LEVER Architecture, and Professor Judith Sheine, University of Oregon, were part of a jury panel to review the students' final work. An ambition in establishing a distinctive graduate program at the Fay Jones School of Architecture and Design is to attain parity with other colleges and schools at the University of Arkansas through actively pursuing design research dedicated to cutting-edge wood technologies, as a major economic leverage of this resource which is widely available in the state of Arkansas.

WOOD MATERIAL CULTURE IN DESIGN EXPLORATION

Design with wood is the second major endeavor in the instruction of this studio–seminar cluster. Speaking at the last timber symposium on design excellence, Sebastian Irarrazaval[9], Arquitecto, uttered the phrase "drawing with wood," which is worth repeating here because the aim of this studio is to insistently encourage students to make wood the center of their design preoccupations. Long unrivaled as a predominant building material, timber went into decline during the industrial revolution in the mid nineteenth century, a period during which concrete and steel were popular. Wood returned en force, however, at Niesky, Germany, when in 1921 Konrad Wachsmann became the chief architect of the construction firm Christoph & Unmack AG where he began exploring industrialized wood panel systems. Later in 1946, he developed with Walter Gropius the Packaged House, which consisted of a prefabricated system ready to assemble on site. [10] Wachsmann stated in his book *The Turning Point of Buildings: Design and Construction* that this process signaled a turning point for housing design and construction.[11]

As seen through the variety of design expressions that were revealed in wood architecture, both inside and outside buildings, wood's appeal has been enduring. A variety of architectural styles can be discerned. For instance, vernacular

Scandinavian buildings heavily influenced Alvar Aalto's architecture, a key figure of midcentury modernism[12] who adopted a humanistic approach and whose many examples of design genius, not only in buildings but also in their featured interiors, including furniture, lamps, and glassware design, were celebrated as art. He was a keen observer of the forest from which he drew his inspiration and elegantly rode the poetics of nature in his designs, as witnessed in the Villa Mairea, a collage of materials amongst the trunks of countless birch trees in the Finnish landscape and a significant dwelling that defines the shift from traditional to modern architecture, a novel style that highlighted the material qualities of wood. In his book *The Soul of Wood*,[13] Juhani Pallasmaa delivers a stirring narrative about the character of wood and skillfully draws metaphorical parallels between the forest and our own human soul and senses through the material qualities of wood.

As Wachsmann saw a turning point in wood's popularity with the rise of prefabrication and industrialization, we see another turning point in response to the exponential growth in the application of mass timber compounded by pressing needs for environmental correction.

The approach adopted in the studio–seminar cluster was inspired from an international architecture master class run by architect and educator Glenn Murcutt, and consisting of a metaphorical engagement of ecology as a strategy for designing human inhabitation catalyzed by and supportive of healthy urban ecosystems, as a result of collaboration and conceptual association between architects and landscape ecologists.[14] Starting in 2000 and for many summers, he regularly offered a two-week studio on green design in Australia. The mornings of the first week were spent exploring the forest, looking at the fauna and flora. Accompanied by a landscape architect and a forester, Murcutt would take students through the woods and explain the local ecology and have them sketch ad hoc details, impressions and diagrams of what they have seen and learned. In this way, Glenn inspired the tree-to-detail-to-building design approach for this studio, as elaborated below.

APPROACH ADOPTED IN STUDIO:

STUDIO MANAGEMENT AND STRUCTURE

The preparatory work in planning the method and content of the studio resulted from the dedicated effort and commitment of the two faculty who maintained true collaboration throughout the semester. For this purpose, they regularly met—at least twice a week—to discuss the progress in studio–seminar and to make any adjustments. Each assignment was collaboratively prepared, fully discussed and approved by the faculty in achieving, first, a smoother working relation between students, and second, a relevant conception and development of the assignments. Even though we aimed at having equal enrollment from each discipline, the summary of students' distribution shows a less than ideal spread: In Spring 2017, six architecture students and six interior design students enrolled in studio. In Spring 2018, six architecture students and six interior design students enrolled in studio. And in Spring 2019, twelve architecture students and one interior design student enrolled in studio, and fourteen architecture student and one civil engineering student enrolled in the seminar. The following numbered assignments 1, 4, 5, 6, 8, 9, 10 were given in studio and 1, 2, 3, 7 in the seminar.

PHASES OF ACTIVITIES ENGAGED IN STUDIO AND SEMINAR

The phases of activities and assignments are described independently of the year of enrollment.

PHASE 1 - FOREST IMMERSION

At the start of the semester students travelled to Monticello, Arkansas, to spend a long weekend in the forest. Phil Tappe and Matt Pelkki, faculty from the School of Forestry and Natural Resources, joined the group, and led the walk through the woods while explaining to students the principles of forest and growth management. As a prelude to the studio project, this immersion gave students an opportunity to examine the amazing processes of life, death, and regeneration of trees, beginning with tree growth before moving to delimbing, logging, and manufactured wood-based products. The consultants acquainted students with the eco-friendly processes that keep our forests healthy and in constant growth, including thinning, harvesting and replanting, as well as visiting a sawmill and a wood company to understand the manufacturing of wood products.

The students' rich sensory experiences were a response to the appealing aesthetics of nature, embodied through an abundance of odors, sounds, tastes, smells, haptic sensations, and visual patterns that fluctuate with time (daily and seasonal) and weather. In addition, students were assigned to record their discoveries through experiential, emotive, and analytical drawings. They responded to the assignment with real enthusiasm (see figure 1a).

PHASE 2 - TREE SPECIES

Groups of three students were assigned to study a tree species, specifically the morphology, height, canopy size, trunk thickness, limbs, bark, leaves, roots, form, order and patterns, textures and shapes, constituents, growth and life cycle (see figure 1b).

PHASE 3 - MANUFACTURED WOOD PRODUCTS

Students examined basic finished wood products and their applications to buildings. This completes the cycle of processing wood from the forest to the final product.

PHASE 4 - WOOD CONSTRUCTIONS

Before engaging the project specifics, the students deepened their familiarity with this material through an assignment regarding the performative and qualitative aspects of wood. The emphasis was on learning about and employing the capabilities

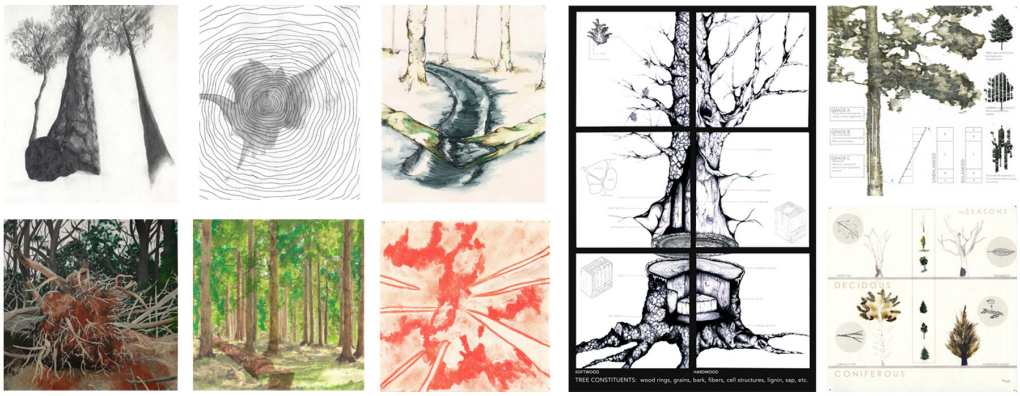

Figure 1. a) Impressions of the forest. b) Analysis of tree species.

of traditional machines and hand tools to produce visual, formal, and assembly changes in wood. This active-learning assignment empowered students to design, build, and physically test their own ideas and approaches to complete construction. Each team was assigned a digitally generated model for the students to produce the artefact through a series of operations, such as planning, bending, laminating, molding, cross lap joining, and others (see figure 2a).

PHASE 5 - GRAIL OF WOOD

Understanding the means of transforming wood material of any size relies on a keen awareness of each wood species' properties and a careful understanding of an individual wood's unique grail. For this assignment, students worked on a block of wood measuring 5½" × 5½" × 18" and, using a minimum of three and a maximum of six discrete operations, applied both digital and traditional tools. Through these operations they experimentally and critically explored the wood block's inherent and intrinsic attributes—with the goal of revealing its grail (see figure 2.b).

PHASE 6 - SITE VISIT AND TOUR OF MASS TIMBER BUILDINGS

The visit to Whistler Village, where the Ski Pavilion was to be sited, was combined with touring many timber buildings located in Vancouver, including the Audain Museum by Patkau Architects.

PHASE 7 - CASE STUDY OF WOOD JOINERY AND ASSEMBLY THROUGH TWO ASSIGNED BUILDINGS

Multidisciplinary teams of students conducted an in-depth study of two architectural projects primarily designed with wood. This began with collecting documentation to study the anatomy of the building by identifying and describing its overarching logic and conceptual goals, and as well to explain the role of wood in the overall building systems, specifically regarding the primary structural elements and the enclosure's layers.

Students also successfully described the circumstances that brought a given building to fruition and their influence on its form and materiality (particularly wood). Through the effort invested in the history of the application of wood, they emerged with an understanding of how such factors have impacted the design and resulted in the specific way wood joints were articulated. This reflection extended to the inherent principles governing the structural system and influence on the generated detail connections. The work was so successful that it will serve as material to introduce to students in the upcoming semesters.

PHASE 8 - TECTONICS OF WOOD JOINERY AND DETAIL ASSEMBLY

Prior to engaging this exercise, students conducted research on designers and critics who have spoken about and designed connections and joints. They also looked for artist sculptors who have worked in wood.

The explicit challenge in this assignment was to conceive of a tectonic connection assembly or joint located at the intersection of floor–wall or roof–wall. In this exercise, students were given the freedom to use both traditional and digital tools to establish elegant assemblies and joineries. Along with these explorations, a series of lectures were given on joinery and the variations between US and Japanese processes, e.g., the presence and absence of nails. The joint was the intersection of mental construing and physical construction, which became the instrumental piece of articulation. As Marco Frascari has stated, "the art of detailing is really the joining of materials, elements, components and building pasts in a functional and aesthetic manner."[15] This active learning empowered students to design, build, and physically test their own ideas through wood constructs (see figure 3a).

PHASE 9 - EDGE FRAGMENT AND MATERIAL SPECULATION

Informed by site, program, material, and spatial strategies, students were tasked to develop and build the Edge Fragment by building a continuum starting from the detail joint-assembly for the design of the Ski Pavilion. In this phase, the connection is then construed with other elements to form the

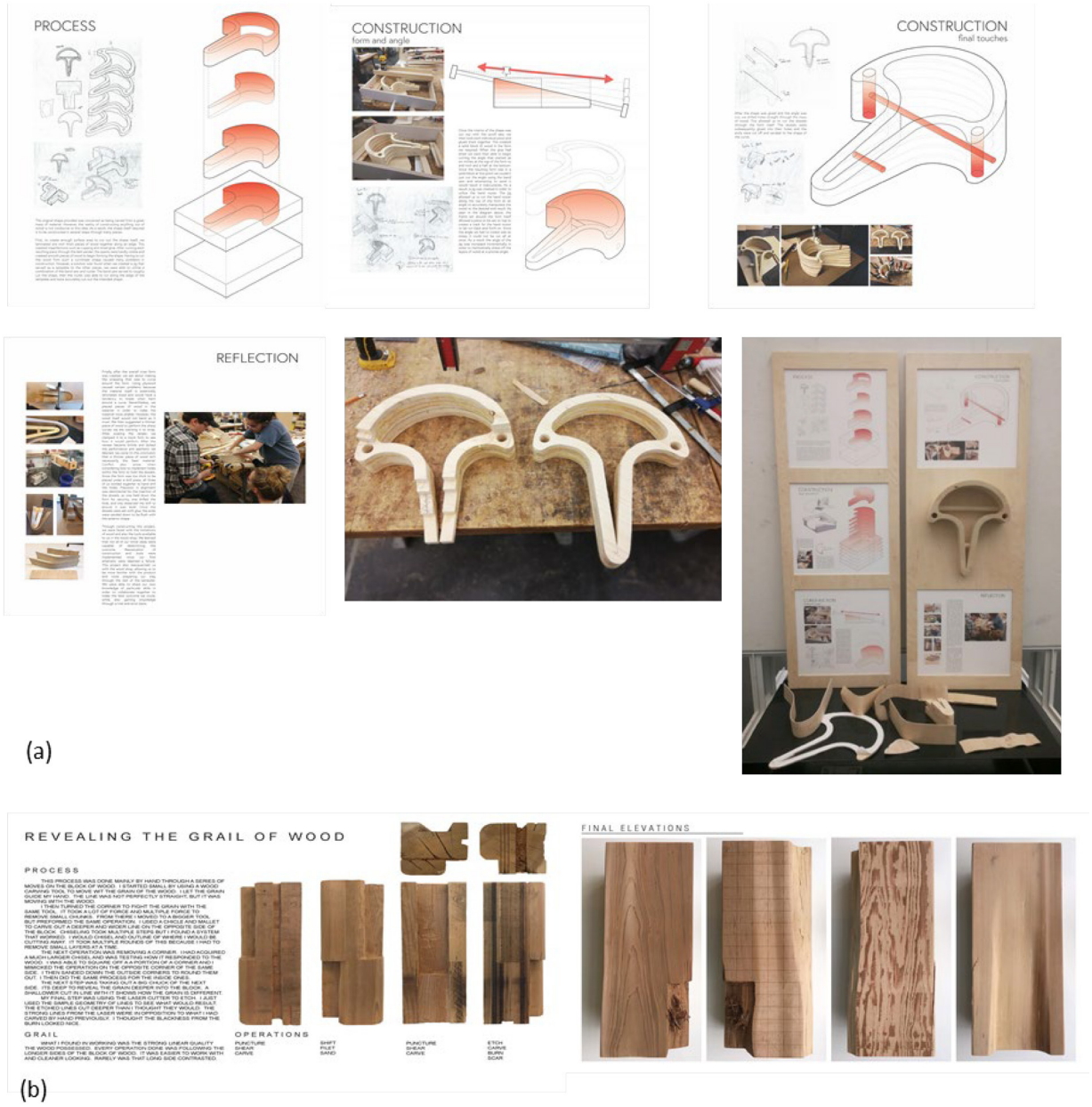

Figure 2. a) Wood construction by a team of students Hannah Both, Abby Critselous, and Jasiel Akin. b) Example of wood grail.

specific envelope with its opacity and transparency play in the achievement of a tectonic language (see figure 3b). Through this prototyping of the building assemblies and connections and enclosure fragments, students then continued to evolve the design of the Ski Pavilion.

PHASE 10 - OVERALL FINAL DESIGN PROJECT

Working with a small and simplified program focused upon the Ski Pavilion was considered essential for our pedagogical objectives to keep students' attention and focus on wood design investigations, and therefore enhance learning. After a first studio on housing, we decided to avoid larger and complex programs, as they took too much time to just resolve the functional relationships, and as such, lessened the opportunity for the students to learn about wood (see figure 4). During this phase, structural engineering consultants invited to review students' work include Robert Malczyk, PE, Equilibrium and Richard Welcher, PE, Vice President & Principal, Tatum-Smith Engineers, Inc.

PRELIMINARY OBSERVATIONS AND OUTCOMES

Despite the recognized benefits of interdisciplinary collaboration, management issues and logistical demands remained a challenge to the smooth running of the studio–seminar cluster, such as lack of simultaneity of class time for the seminar and the civil engineering course, the uneven number of enrolled

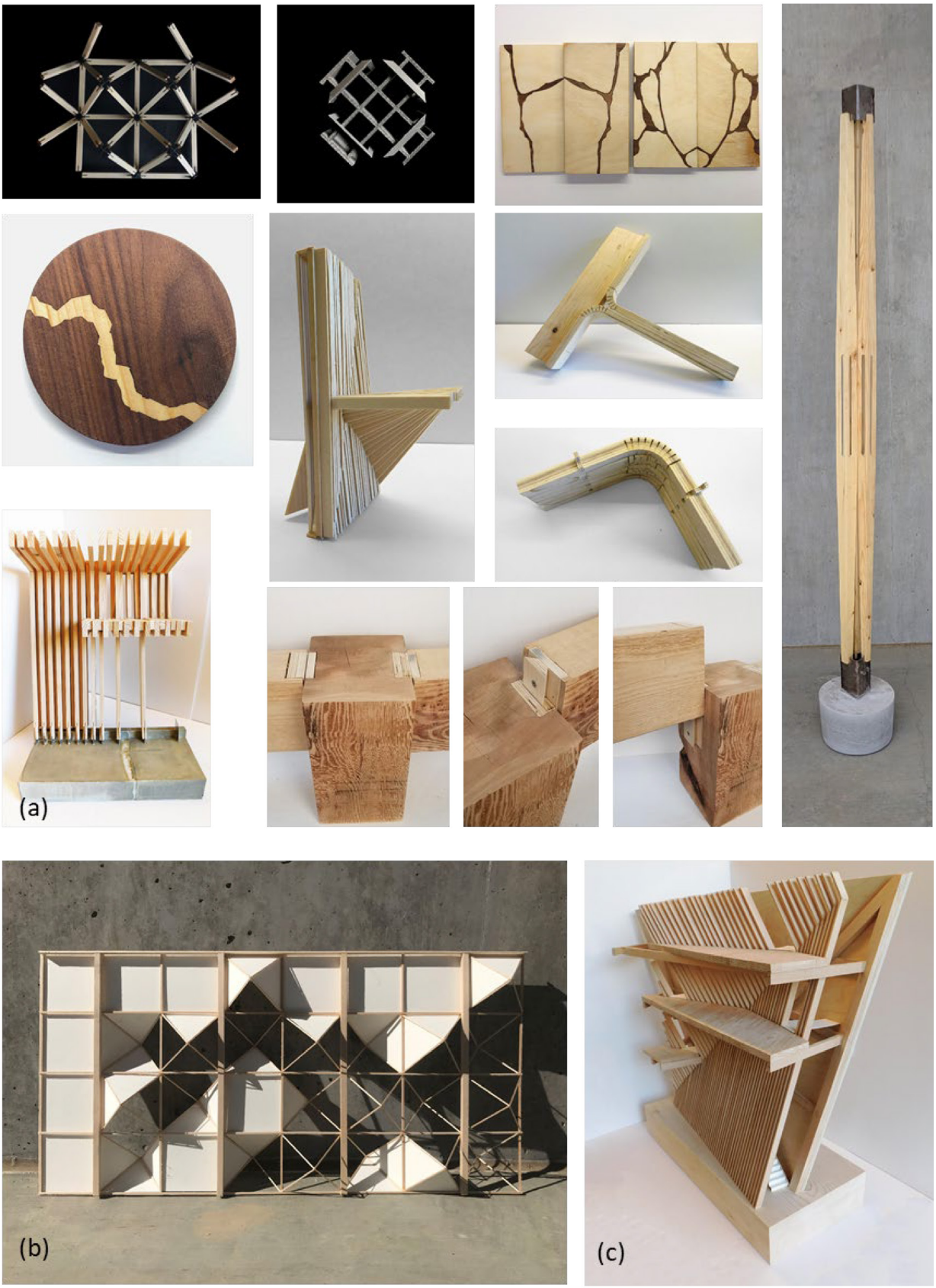

Figure 3. a) Joinery and connection exemplars. b) Edge fragment of Sky Pavilion by Austin Ply and Nick Ryan, c) Edge Fragment of Sky Pavilion by Hannah Both, Abby Critselous, and Jasiel Akins

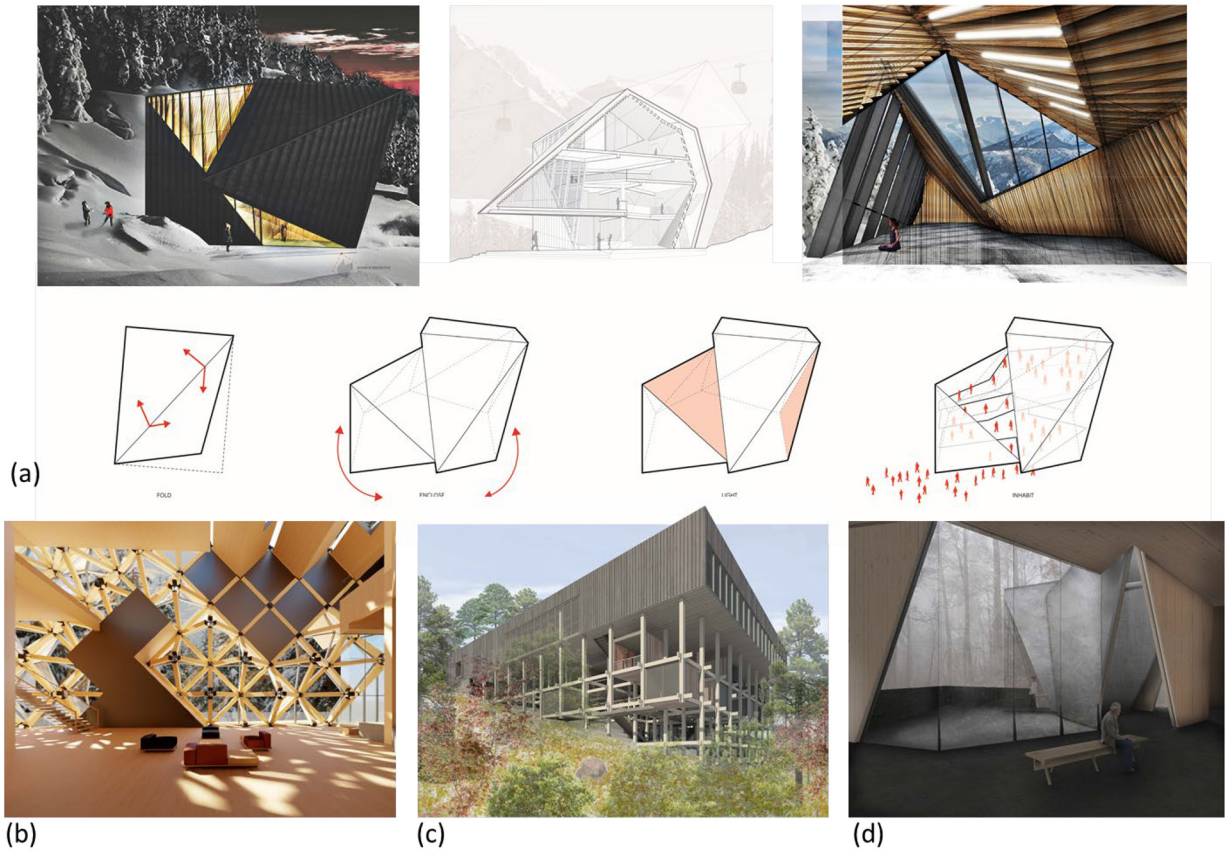

Figure 4. a) Ski Pavilion by Hannah Both, Abby Critselous, and Jasiel Akins. b) Ski Pavilion interior view by Austin Ply, and Nick Ryan. c) A Retreat by Graham Gordon and Jumin Kim. d) A Retreat by Heidi Matthews and Su Su Soe San.

students from different disciplines, and their readiness for team work.

Many entering students were clearly not prepared for the exigencies of teamwork, especially between students of different disciplines. As shown in preliminary survey results conducted in studio and seminar, some students conveyed their unhappiness with peers who did not equally contribute to the team's efforts. Additionally, the demands from other classes and their part-time jobs reduced the team's ability to collectively meet outside of studio hours. At the beginning of the semester, some students had difficulty to design as a team; make decisions, equitably distribute tasks, recognize each other's unique contributions, manage disagreements and differing goals, negotiate differences in beliefs and styles of working, and ultimately develop a commitment to collaboration.

The fact that most students entered the studio without prior collaborative skills, resulted in significant time investment and constant vigilance of the faculty to impart a successful evolution within each interdisciplinary team. Faculty led frequent studio discussions to provide students a forum to share the challenges they were confronting. The voiced concerns at these meetings largely centered on procedural or project specific questions or requests while those that had serious concerns about team collaboration, private meetings were held with faculty. Both interdisciplinary faculty were present at all meetings with students outside studio. Ultimately, no collaborative conflicts were unsurmountable—with the exception of one, which after multiple attempts at resolution necessitated the team of two to separate and work individually for the remainder of the semester.

Students' commitment to working through personal and disciplinary differences and resulting in intact and productive teams at the semester's end were attributed to their observation of a respectful leadership collaboration between the interdisciplinary teaching team, and to the reception of a consistent and firm message about the value of collaboration from a unified faculty. Students in the most successful teams grew to be learned communicators as they came to understand the value of contributing their individual expertise while also listening to and incorporating the strengths and priorities of their partners.

Furthermore, students tended to be more responsive to their respective disciplinary instructor and, at times reluctant to comply with directions or to value input from the other instructor. The occurrence of this behavior was less prevalent

in courses where the consistent participation and presence of both faculty as a team was prioritized and consistently practiced.

Overall, the studio's design project was quite challenging because students were not accustomed to starting the design process with postulated joinery and assembly. Each iteration of the studios resulted in high quality architecture/interior design students work and advanced learning about conventions and potential innovations of designing with wood. In particular, excellent design projects and wood investigation results were achieved in the last studio–seminar, as shown in figure 4. The stronger design performance outcomes suggest the benefits of using this design approach in upcoming MDES studios–seminars to enhance students' connection with the nature and possibilities of this material. Finally, more detailed observations and feedback about interdisciplinary collaboration and learning resulting from a thorough analysis of surveys conducted in studio and seminar will be the subject of an upcoming publication which will undoubtedly shed more light on the running of the upcoming graduate program. The Chancellor Innovation and Collaboration Fund supported the development of this work.

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