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ACQUIRING, THINKING & GENERATING KNOWLEDGE: A PROGRESSIVE EDUCATIONAL FRAMEWORK FOR TIMBER ARCHITECTURE

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ABSTRACT: The timber architecture education framework at Zhejiang University (ZJU), driven by Lab MUGO, is a comprehensive tripartite structure that includes undergraduate basic training, postgraduate advanced training, and doctoral research training. Over the course of four years, this framework has achieved significant milestones, including pedagogical innovations like tiered curricula, groundbreaking doctoral research, national competition successes, and international initiatives such as global summer schools. This paper examines the implementation of the framework, evaluates its achievements and experiences, and proposes strategic improvements through curriculum restructuring and enhanced global competency. These enhancements strive to consolidate ZJU's role as a key player in timber architecture education in China, propelling sustainable architectural development across China and extending its influence globally.

KEYWORDS: timber architecture, progressive educational framework, achievements and experiences, training programmes, China

1 – INTRODUCTION

In China, approximately 300 higher education institutions offer architectural programmes [1], yet only a select few specialise in timber architecture courses. On one hand, the market share of timber construction in contemporary China remains minimal, resulting in a low demand for specialists in this field. On the other hand, current timber architecture courses primarily focus on Chinese historical and traditional wood-frame construction, rarely providing insights into contemporary practices or innovations.

Against this backdrop, the Department of Architecture at Zhejiang University (ZJU) stands as a unique exemplar. After four years of dedicated practice and exploration, the educational framework for timber architecture, led by Lab MUGO in collaboration with other faculties, has been further developed. This comprehensive educational framework encompasses three modules for undergraduate, postgraduate, and doctoral students, respectively.

This paper reviews the practical methods and training outcomes of this framework and analyses its reform direction aligned with contemporary developments in China's building industry.

2 – EDUCATIONAL FRAMEWORK FOR TIMBER ARCHITECTURE

Lab MUGO's timber architecture pedagogical framework encompasses three progressive academic modules within the higher education system, corresponding to bachelor's, master's, and doctoral degree programs. This tripartite structure comprises: 1) foundational training to stimulate undergraduate interest, 2) specialized advanced education for master's candidates, and 3) research-intensive cultivation for doctoral advancement (Fig. 1). The curricular progression systematically transitions from fundamental knowledge acquisition through analytical skill development to original research innovation. This structured approach ensures that students at each academic level receive tailored training that prepares them for the next stage of their academic and professional careers.

Undergraduate Module. The undergraduate module, accessible to students in grades two to four, encompasses a broad array of courses in theory, design, and practice. Its objective is to enhance students' interest and design capabilities in timber architecture. It comprises diverse programmes such as *Chinese Architecture History*, *Traditional Building Mapping*, *Timber Architecture*

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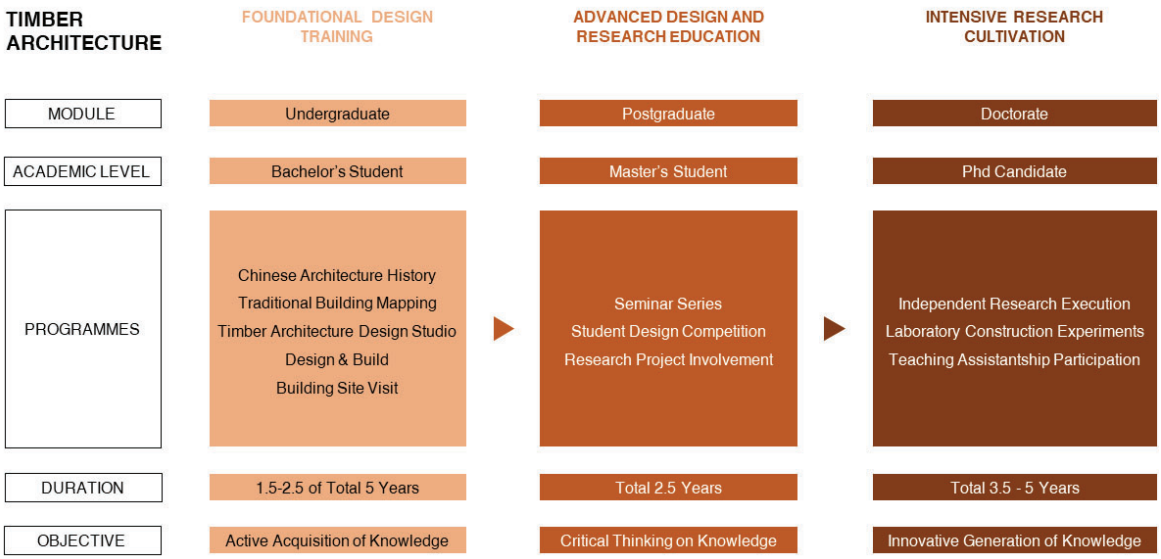

Figure 1. Timber architecture educational framework.

Design Studio, as well as *Design & Build* and *Building Site Visit*. The module is designed to provide a solid foundation in timber architecture, integrating theoretical knowledge with practical skills.

Postgraduate Module. The postgraduate module caters to Master's students pursuing timber architecture design expertise. It involves a spectrum of programmes, including theoretical analyses and case studies, participation in international and national timber structure competitions, involvement in research sub-themes, and visits to prefabrication factories and construction sites. The objective of this module is to augment students' capabilities in becoming more specialised in the design of timber buildings and fostering their potential interest in research.

Doctoral Module. The doctoral module for PhD candidates not only mandates students to independently conduct specialized research themes and construction experiments but also involves their participation in teaching activities for undergraduate students. The aim is to train students to become qualified timber architecture researchers, capable of contributing to the field through original research and knowledge dissemination.

3 – EXPERIRENCE AND OUTCOMES

Over a four-year iterative development cycle, the educational framework has demonstrated structural maturity through phased implementation. This refined system currently supports an annual cohort of 100 participants, with stratified enrollment distributed as 80 undergraduates, 15 master's candidates, and 5 doctoral researchers. The evolving pedagogical approach continues to yield remarkable scholarly outputs, as evidenced by students' progressive academic accomplishments.

3.1 UNDERGRADUATE MODULE

In undergraduate education, the dissemination of knowledge about timber construction tends to emphasize the integration of knowledge and application. Specifically, it involves teaching students how to quickly understand various structural types of timber buildings, modern engineered wood and its derivatives, as well as their usage scenarios, and the different connections between timber components. By planning diverse design themes, students are encouraged to apply engineered wood in actual architectural design processes, thereby recognizing the particular considerations needed when designing with timber structures compared to other structural forms.

3.1.1 Thematic design studio

The *Thematic Design Studio* is an architectural design class offered by ZJU for fourth-year undergraduate students in architecture, scheduled over the spring and summer semesters, each for 8 weeks. Involving dozens of instructors, each responsible for a specific theme, a diverse array of design themes is provided for students to choose from. Timber architecture design was incorporated into the series in 2023, representing a rather unique category within the curriculum, with relatively high demands on the students' acquisition and transformation capabilities of relevant knowledge. After 16 weeks of focused training, students are expected to utilize modern engineered timber to complete a

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comprehensive design proposal for a small to medium-sized building. The course progresses through three structured phases (Tab. 1):

Table 1: Research projects, in which master's students involved.

Timber Architeture Design Studio	**Phase**	
	1. Foundational Learning	Theoretical instruction
		Case study analysis
		Field studies
	2. Technical Design Development	Site planning
		Functional layout
		structural systems
		Wood-based product selection
		Connection detailing
	3. Design Representation	Technical drawings of plans, elevations, and sections and detailed connection
		Physical modelling of entire building and critical joints

Phase 1: Foundational Learning. The first phase establishes foundational knowledge through theoretical instruction and case study analysis. Students acquire fundamental theoretical knowledge of timber structures, analyse classic timber construction cases, and study modern timber connection types and characteristics. Field studies complement classroom learning, with visits to completed timber buildings in Hangzhou and neighboring regions like Shanghai and Jiangsu.

Phase 2: Technical Design Development. This phase develops technical competencies in architectural design and timber construction. Under instructor guidance, students develop comprehensive design solutions addressing site planning, functional layout, structural systems, wood-based product selection, and connection detailing. Timber-specific design considerations often challenge students' preconceptions, leading to common errors. For instance, influenced by steel structure, students designed disproportionately too small cross-sections of timber beams and columns. A recurrent design oversight involved directly exposing timber structural elements to exterior conditions without implementing protective measures against solar radiation and moisture infiltration, a practice stemming from misconceptions derived from concrete construction.

Phase 3: Design Representation. In the phase, students are supposed to communicate their timber architecture designs through technical drawings and physical modelling (Fig. 2). The technical drawings include accurate plans, elevations, and sections, as well as detailed connection representations using enlarged or axonometric views. The entire building modelling represents the architectural form at appropriate scales, added with 1:5 scaled models of critical joints, enabling better understanding of material and structure in timber.

3.1.2 Design & Build

Design & Build, also known as *Architectural Construction Basics*, is an elective course designed for third and fourth-year students across the department. The primary objective of this course is to enable students to design small furniture or structures while actively

Figure 2. Selected student works in design studio.

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participating in the manufacturing process, ultimately bringing their design plans into reality. Utilizing wood due to its excellent processability and relatively lightweight nature makes it a preferred choice for this course. Over the past two years, the author has been guiding students in the course, with a focus on small timber installation in the university campus (Fig. 3).

The course spaned 8 weeks in total. During the first four weeks, students completed their installation designs, which included individual design work, instructor review sessions, design optimization, and collaborative group efforts, culminating in the selection of a final design for construction. From week five onwards, students engaged in carpentry workshop tasks such as sawing, sanding, planing, and painting. By the eighth week, pre-fabricated components would be transported to the outdoor installation site for overall assembly. Considering the feasibility of completing the entire course objective within a 8-week timeframe, only pine lumber shorter than 2.5 meters is permitted for design purposes. All necessary materials have been purchased and prepared in advance to ensure a smooth start to the course.

The 20 enrolled students have demonstrated exceptional enthusiasm for innovative design and construction using timber. While this course represents their first systematic exposure to timber-based design principles, many participants lacked a clear understanding of the inherent characteristics of wood and often failed to establish a cohesive connection between joint detailing during the design phase and subsequent processing stages. To address these challenges, it was crucial for instructors to consistently emphasize the importance of focusing on appropriate connection methods for wooden structural components. To facilitate this learning process, supplementary materials such as reference examples or templates were provided. Students were also encouraged to design wooden joints with easily purchasable connectors. For undergraduates who have only recently become acquainted with timber construction, we believe that achieving operational proficiency in applying existing timber construction methods already satisfies the educational objectives of this course. It is believed that

Figure 3. Course process in Design & Build.

applying mature timber construction techniques has achieved proficiency for the undergraduate students who were newly exposed to timber construction. This approach already fulfilled the course's objectives.

3.2 POSTGRADUATE MODULE

Graduate-level timber architecture education is delivered through three distinct approaches: engaging in seminar series, design competitions, and research projects. These educational initiatives aim to enable master's students to deepen their understanding of wood as a building material across various aspects of structural safety, energy efficiency, carbon reduction, indoor environment, and sustainable construction practices. Building on the foundational skills in timber-based architectural design acquired during their undergraduate studies, graduate students are further challenged to propose innovative and practical solutions through research and exploration.

3.2.1 Seminar series

Every autumn semester, Lab MUGO offers an 8-week seminar series tailored for first-year graduate students as an elective major course in timber architecture. The two course instructors provide a comprehensive knowledge framework both on traditional Chinese timber techniques and modern timber construction methods. Practicing architects and experts with professional experience in timber construction are invited to deliver guest lectures either online or in person. The seminar series addresses a wide range of topics, including contemporary building design experiences, the cultural features of traditional timber building, diverse construction methods across different eras, and the evolution of woodworking craftsmanship (Tab. 2). The seminar series also includes field trips to high-quality timber buildings, allowing students to interact directly with technical professionals during site visits. These practical experiences enhance students' understanding of the design process while fostering a strong connection between theory and application.

Table 2: Themes involved in the seminar series.

	Theme	Subtheme
Timber Architeture Semiar Series	***Basics***	Materials and products
		Structural systems
	History and culture	Traditional woodworking craftsmanship
		Cultural connotations of historical building
		Chinese mortise-and-tenon joint
	Design	Timber architecture design in China
		Design practice in Germany and Canada
		Digital design methods
	Sustainability	Sustainablity of timber construction

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In addition to the regular seminar activities, students engage in debates as part of the course requirements. The course encourages critical analysis of timber architecture from cultural, technical, and social perspectives. Students are then tasked with taking either a positive or negative stance on certain debate topics proposed by the instructors. During the final class, students present their arguments in a live debate to defend their chosen side. This format is designed to foster critical thinking about issues related to timber construction while encouraging students to go beyond superficial knowledge absorption. An important debate topic focuses on *Integration of Traditional and Modern Timber Construction*, which is also a subject frequently discussed in the course and one of the contemporary challenges in the Chinese building industry. It also explores the integration of historical elements with modern practices to enhance students' understanding of how traditional and innovative approaches can complement each other in timber architecture projects.

Building the comprehensive knowledge framework in timber architecture is challenging due to the extensive and diverse content, including wood properties, new materials, structural systems, fire resistance, corrosion prevention, and sustainable performance. Traditional in-class lecturing often lacks students' engagement in learning. In response, Lab MUGO has incorporated the Massive Open Online Course (MOOC) platform and knowledge graphs into the teaching methods to enhance flexibility and interactivity of students' learning activities.The developing large-scale knowledge graph, based on global timber construction projects, is open to all students for queries and exploration, who can delve into interconnected knowledge networks based on their individual interests.

3.2.2 Student design competition

Master's students interested in timber structure design are encouraged to participate in the annual *National University Timber Structure Design Competition*. The event is hosted by the Chinese Ministry of Education each year. Recent competition design objectives have included various timber-based load-bearing structures such as pavilions, bridges, conference centers, and agricultural greenhouses. As the competition entries must encompass both architectural design and structural design, participating teams are required to be interdisciplinary teams composed of architecture and civil engineering students. Similarly, the judging panel includes both architects and structure engineers in timber, placing high demands on participants' comprehensive application of timber construction knowledge (Fig. 4).

On the one hand, the competition serves as an accelerator for deepening students' understanding of timber knowledge. Participants must proactively and intensively study timber-related subjects within a tight timeframe, typically 1-2 months. This involves multifaceted learning contents, including the novel materials and application methods of engineered wood, Chinese and foreign timber construction codes and standards, common joints and connections in timber structures, and the use of timber design calculation software. Such competition-driven

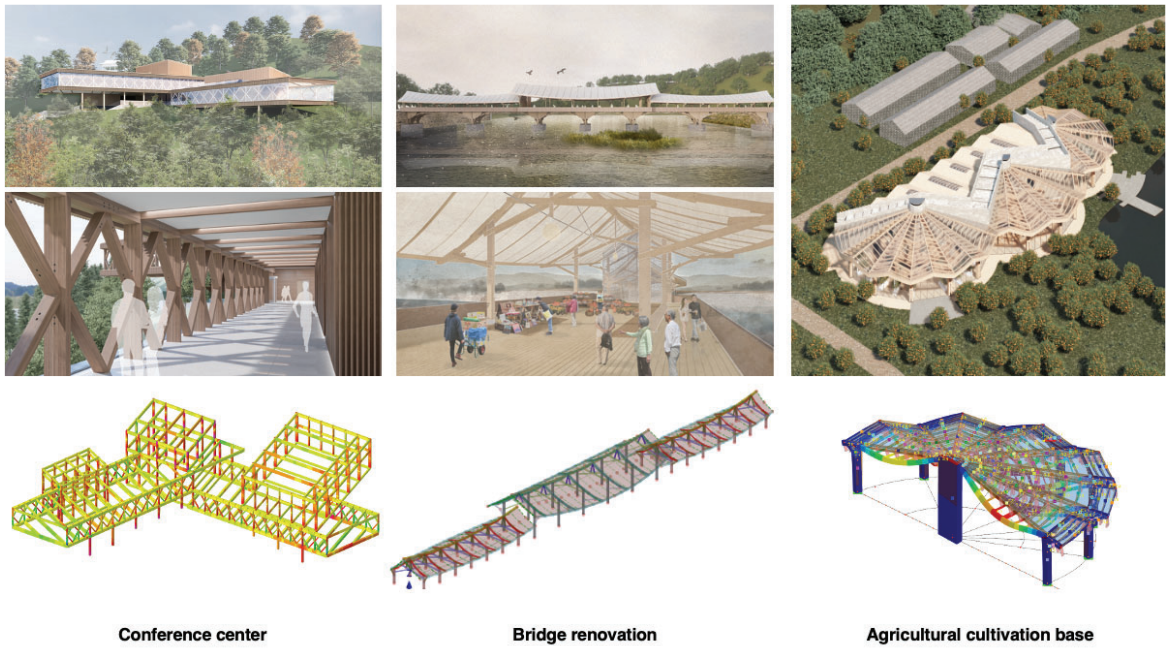

Figure 4. Award-winning competition entries.

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learning with full enthusiasm complements classroom education effectively.

On the other hand, students should aim to propose innovative solutions in order to stand out among numerous competition entries. Conventional designs often get eliminated in preliminary rounds due to mediocrity. So students must continuously reflect on how to translate theoretical knowledge into practical design while clearly demonstrating the rationality and feasibility of such transformations in their submissions. Groundless whimsy lacking theoretical foundations will not gain jury's approval. For instance, applying small-dimension timber to large-span timber roofs may seem creative, but its realization still requires rigorous structural calculations and appropriate connection methods for components presented in the design submission.

Since 2021, Lab MUGO has guided students four times in participating in the *National University Timber Structure Design Competition*, and secured second-place awards in three of them. Competition entries include conference center, bridge renovation, and agricultural cultivation base. During the mentoring process, we provided regular feedback to participants and encouraged interdisciplinary collaboration between architecture and civil engineering students. Most importantly, we focused on stimulating students' self-driven initiative and nurturing their passion for timber architecture.

3.2.3 Research projects

At Lab MUGO, graduate students are required to engage in research activities from the start of their graduate studies. These activities may either be part of on-going research projects or newly approved proposals with small research objectives and predefined frameworks. Typically, students are assigned relatively straightforward research tasks with a cycle of approximately one year. Through these projects, they gain deeper insights into timber construction-related research fields and receive basic training in literature review, case study and scientific paper writing. The outcomes of these research activities often serve as a crucial foundation for students' degree thesis.

Currently, the completed or ongoing research projects for master's students focus on various aspects of contemporary timber construction in China, including: digital design for simplified assembly, typological language of timber structures, circularity of small-scale timber building, timber-based house renovation, and product-oriented timber building design, etc.

These topics feature clearly defined research objectives and methodological frameworks, making them accessible for postgraduate students new to academic research. During their research processes, students often encounter deviations from initial research plans. In such cases, they must independently refine their approaches through critical thinking and discussions with the supervisor to identify viable solutions that align with project goals.

Targeted research training for master's students helps uncover and enhance their academic potential, encouraging outstanding students to pursue doctoral studies after earning their master's degrees, provided they maintain sustained research interest in timber construction.

3.3 DOCTORAL MODULE

The objective of doctoral training is to cultivate qualified researchers who can engage in specialized timber construction research at academic institutions or pursue teaching careers in universities. The independent research capability serves as a critical indicator for evaluating our educational effectiveness. The doctoral candidates are no longer seen as knowledge recipients, but as academic assistants in identifying emerging research frontiers, expanding disciplinary dimensions, and enhancing investigation depth. Ultimately, they create and disseminate new knowledge through their doctoral research.

Based on these considerations, the doctoral module comprises two core training elements: independent research execution and teaching assistantship participation.

3.3.1 Independent research execution

Upon enrollment, doctoral students start in research projects under the professor's supervision. Within the general framework of modern timber architecture, students are required to define specific research directions, building upon their individual master's background and personal interests. By their second year, students must submit a dissertation proposal for review by an academic committee. The evaluation criteria include scientific and social merit, methodology, anticipated outcomes, innovation of the research proposal. As supervisor, the author must assists students in refining research topics, particularly emphasizing solutions to critical challenges hindering contemporary timber construction development in China. Lab MUGO currently has five doctoral students, three of whom have successfully passed their proposal defenses, and

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advanced to PhD candidacy status. These three candidates have established well-defined research projects (Fig. 5):

MEGA Wood (Mini Element, Grand Architecture). The project investigates integrated design methods merging structural engineering and architecture, focusing on large-scale building configuration using small-dimension timber components.

Bonda Dome. This research develops human-machine collaborative workflows for precision fabrication of irregular timber members applied to curved structure surfaces.

ReHut. This project proposes evaluation metrics, design methods, and strategic frameworks for circular architecture systems featuring disassembly and reassembly.

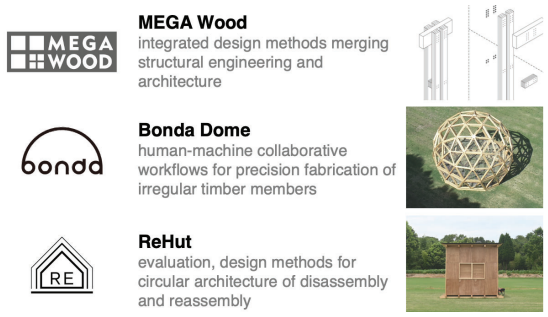

Figure 5.Three on-going PhD research projects.

The approved research topics address critical gaps in contemporary timber construction, i.e. integrated design in *MEGA Wood*, digital fabrication in *Bonda Dome* and Circular economy in *ReHut*. Through execution of these research projects independently, the PhD candidates aim to generate novel knowledge advancing timber construction.

3.3.2 Teaching assistantship participation

While conducting independent research projects, doctoral students actively participate in assisting with our lab's teaching activities, particularly by applying their research findings to instructional contexts. We encourage doctoral candidates to deeply integrate their research topics into undergraduate teaching, thereby constructing a closed-loop research-teaching ecosystem. This appoach not only enhances teaching quality but also serves as a significant driver for the academic capabilities and career development of doctoral students.

In the *Thematic Design Studio*, one doctoral student has guided the undergraduates in lattice structure, a long-span building design method utilizing small-dimension timber, applying his research outcomes on roof configuration design. During *Design & Build*, doctoral research on circular construction and precise fabrication informs hands-on teaching, creating practical scenarios for translating theoretical findings into real-world applications.

This integration of research and teaching employs teaching-driven learning and establishes a feedback loop from the classroom back to research. Applications in teaching serve as practical tests for proposed strategies, while course outcomes provide additional data samples for doctoral studies. Benefits of this approach include: 1) Enhanced research motivation. By teaching, doctoral students gain direct insight into the applied value of their research; 2) Novel perspectives: Undergraduates, with their limited preconceptions and unconstrained thinking, often pose unconventional questions that may offer fresh perspectives on timber architecture research; 3) Professional preparation: As future academics, doctoral students develop essential teaching competencies through early experiences, addressing a core requirement for future's university faculty positions.

4 – REFLECTIONS

After four years of implementing and refining our progressive timber architecture educational framework, we have observed substantial achievements in both research innovation and pedagogical outcomes. While celebrating these successes, we maintain critical reflection on areas requiring further enhancement. Student feedback analysis conducted through participant discussions and post-course evaluations has yielded critical insights, with two paramount revelations emerging, that are early-stage knowledge framework development and global competency cultivation.

4.1 EARLY-STAGE DEVELOPMENT

In the current educational framework, comprehensive knowledge of timber construction is gradually established at the postgraduate level through seminar-style courses. On one hand, the existing undergraduate architecture curriculum does not prioritize timber construction as an important and emerging architectural typology, failing to offer dedicated courses for students. On the other hand, although the graduate-level seminar series are open and accessible to undergraduates, scheduling conflicts and study workload have resulted in no undergraduate participation.

Therefore, due to the lack of a systematical knowledge framework, undergraduates engaging in timber construction design exercises often struggle to

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understand the underlying reasons behind design decisions, such as structural requirements, wood processing and fabrication limitations, or material-specific considerations. They tend to imitate the formal aesthetics of renowned buildings while overlooking the technical rationale behind. Since they often reference the same precedents, this leads to homogenized design outcomes, hindering innovation of timber architecture.

Establishing a comprehensive timber knowledge framework earlier in the curriculum could address these issues. For instance, introducing a theoretical elective course in the third year of undergraduate studies would allow students to systematically acquire relevant knowledge. Additionally, the previously mentioned MOOC and knowledge graph platforms could help break down knowledge acquisition barriers, creating more open and accessible pathways for timber architecture education.

4.2 GLOBAL COMPETENCY

Currently, ZJU's timber architecture education primarily focuses on China's context, aiming to cultivate professionals capable of addressing domestic development challenges through both teaching and research. However, China's progress in contemporary timber construction lags behind countries in Europe and North America. It is to believe that the university education experiences in those countries offer valuable insights for enhancing our programs.

To bridge this gap, we are actively inviting international experts from the UK, Germany and Canada to deliver guest lectures, significantly broadening students' international view. Additionally, through collaborations with foreign institutions such as Fachhochschule Campus Wien, ZJU sends students to participate in international timber structures workshops, thereby broadening their knowledge in the global scale.

Simultaneously, Lab MUGO seeks partnerships with global timber architecture experts to conduct joint research, enabling master's and doctoral students to engage in international scientific collaborations. We encourage students to present their research at significant international conferences, particularly the World Conference on Timber Engineering, as a crucial step in building foundational international networks for these future researchers.

Looking ahead, we are preparing to launch an annual Global Summer School, scheduled for two weeks in July or August. This initiative will enroll 30 students worldwide, with a focus on China's Belt and Road Initiative countries, to study and practice timber construction and sustainable building methods in Hangzhou, China. Through this program, ZJU will disseminate timber architecture knowledge to young students from such countries, contributing to global sustainable development. The inaugural programme is planned to commence on July 21, 2025.

5 – CONCLUSION

This paper systematically reviews the timber architecture educational framework established under the leadership of Lab MUGO. The framework implements progressive training modules tailored to three academic levels within ZJU's Department of Architecture: undergraduate studies emphasizing knowledge acquisition, master's studies focusing on critical knowledge evaluation, and doctoral research prioritizing creative knowledge construction.

These three stages form a hierarchical progression, gradually expanding learners' breadth and depth of understanding in timber construction. Through diverse course formats and training methodologies, the framework has achieved significant outcomes and accumulated valuable experience. With continuous optimization of the curriculum framework, such as early establishment of knowledge systems and strengthened international collaborations, we are confident that our timber architectural education will develop distinctive characteristics, cultivating outstanding timber architecture design and research talents for China and the global community.

6 – REFERENCES

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