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Bridging Cultures in Engineering Education: Lessons from Civil and Electronic Labs in China

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Abstract*– Transnational education (TNE) presents opportunities to adapt and refine engineering laboratory teaching across diverse cultural and institutional contexts. This study examines the development and implementation of redesigned civil and electronic engineering laboratory practices delivered to undergraduate students in China. The work explores how structured, concept-centred, and culturally responsive laboratory design can support engagement, inclusivity, and conceptual learning in large-cohort practical settings. A design-based research methodology was employed, enabling iterative refinement of laboratory interventions through cycles of implementation, observation, and evaluation. Data were gathered through facilitator reflections, structured observations, student focus groups, learning artefact review, and learning analytics. The redesigned laboratories incorporated scaffolded digital guides, role-based peer collaboration, formative micro-assessments, and concept-first experimental sequencing. Findings indicate that highly structured laboratory scaffolding reduced cognitive load and improved workflow efficiency, while concept-centred experimental activities strengthened connections between theoretical knowledge and experimental evidence. Inclusive participation mechanisms, including rotating team roles and multimodal feedback channels, broadened student engagement and supported diverse learning needs. Student feedback highlighted improved confidence in applying engineering principles and increased awareness of uncertainty and variability in experimental practice. The study contributes evidence-based design patterns for scalable laboratory teaching within TNE environments and highlights the importance of culturally responsive instructional design. The findings provide a foundation for future adaptation of large-cohort laboratory models across international engineering education contexts.

***Keywords*-- Transnational Education, Electronic/Computer Engineering, Civil Engineering, Engineering Education, Ireland, China.**

I. INTRODUCTION

Transnational education (TNE) continues to reshape how engineering is taught and learned, creating new opportunities—and pressures—for institutions to deliver practical, high-quality laboratory experiences at scale. As universities expand partnerships and programs across borders, educators must navigate differences in culture, language, prior educational preparation, and institutional norms while sustaining student engagement and inclusion in large student cohorts. This paper investigates these dynamics through the lens of civil and electronic engineering laboratory teaching in China, and how lessons learned were subsequently adapted to improve large-class engagement in an Irish university context.

Large classes pose well-documented challenges for practical engineering education: uneven participation, variable prior knowledge, limited instructor attention, and the risk of labs devolving into procedural checklists rather than conceptually rich learning. These challenges are amplified in TNE settings where cultural expectations about participation, help-seeking, and assessment can shape student behaviours. In the Chinese context, students often demonstrate strong discipline and exam-oriented focus, with high respect for authority and peer accountability; however, this may coexist with hesitance to speak up spontaneously or to focus more on the process as opposed to the end-product. Conversely, Irish classrooms tend to exhibit greater diversity in prior technical experience and learning preferences, alongside expectations for dialogic teaching and visible opportunities for student voice. Recognising and designing for these differences is crucial when translating successful practices across borders.

Drawing on direct teaching experience, the approach presented here emphasizes three mutually reinforcing pillars: (1) structured peer collaboration that distributes roles, responsibilities, and reflection in teams; (2) scaffolded digital lab guides that prioritise conceptual understanding before procedure, incorporate just-in-time resources, and enable self-paced progress; and (3) formative feedback loops — including low-stakes checks, real-time response tools, and brief reflective prompts—that foster metacognition, co-creation, and inclusion. In China, these strategies promoted predictable workflows, reduced cognitive overload, and normalised collaborative problem-solving. Critically, they also provided safe, structured channels for student voice without relying solely on spontaneous contributions.

Translating this model to a country like Ireland requires adaptation. Greater heterogeneity in student backgrounds and language proficiency calls for multiple entry points into each lab (e.g., baseline, extension, and advanced tasks), explicit framing of learning outcomes, and accessible asynchronous walkthroughs to support students who need additional time or alternative explanations. To elevate conceptual understanding over rote procedure, labs are redesigned around phenomena — signal integrity and measurement uncertainty in electronics; measurement, materials behaviour, and structural response in civil engineering — so that students linked theory to observation and design trade-offs. The integration of wellbeing considerations — clear pacing, predictable milestones, and community-building activities — further supports engagement and persistence in large cohorts.

This paper contributes a comparative account of lab design across China and Ireland, analysing how cultural expectations, institutional structures, and student diversity shape engagement and learning. It offers a set of adaptable design patterns — team roles and contracts, layered digital guides, formative micro-assessments, and transparent criteria — that are both scalable and culturally responsive. The paper provides a practical roadmap for educators seeking to deliver conceptually rich, inclusive laboratory experiences for large classes, while leveraging insights gained from transnational teaching to enhance local practice.

II. Literature Review

Transnational Education (TNE) has become a defining feature of global higher education, enabling institutions to deliver programs across borders and cultures while maintaining academic standards and learning outcomes [1]. In engineering disciplines, TNE introduces unique challenges due to the practical, hands-on nature of laboratory work, which often requires adaptation to local contexts and resources [2]. Studies highlight that successful TNE initiatives depend on cultural responsiveness, pedagogical flexibility, and robust support structures to ensure equitable engagement for diverse student cohorts [3-5].

Ireland and China represent two distinct educational cultures with contrasting approaches to teaching and learning [6]. Chinese higher education is often characterized by hierarchical classroom dynamics, strong exam orientation, and high respect for authority [7], which can influence student participation and help-seeking behaviours [8]. Conversely, Irish engineering education emphasizes interactive learning, student voice, and formative assessment practices, reflecting broader Western pedagogical traditions [9-10]. These cultural differences have implications for laboratory-based learning, where collaboration, communication, and conceptual understanding are critical [11].

Research on engineering education in China underscores the importance of structured guidance and clear procedural frameworks to support student confidence in practical tasks [12]. Digital scaffolds, such as interactive lab manuals and asynchronous resources, have been shown to enhance accessibility and reduce cognitive overload in large classes [13-14]. Similarly, peer collaboration strategies—such as role-based teamwork and structured reflection—are effective in promoting engagement and mitigating language barriers in multicultural cohorts [15].

In the Irish context, large-class laboratory teaching faces persistent challenges, including resource constraints, variability in prior knowledge, and maintaining inclusivity [11,16]. Emerging literature advocates for blended approaches that combine physical lab experiences with digital tools, enabling real-time feedback and flexible pacing [17-18]. Conceptual emphasis—prioritizing understanding of principles over rote procedural execution—has been linked to deeper learning and improved retention in engineering labs [19].

Despite these insights, comparative studies examining how lessons from Chinese engineering education can inform scalable, inclusive lab design in Ireland remain limited. This paper addresses this gap by analysing transnational teaching experiences and identifying adaptable strategies—such as scaffolded digital guides, formative feedback loops, and culturally responsive collaboration models [20]—that enhance engagement and learning outcomes in large Irish cohorts.

III. Methodology

This study adopts a design-based research approach to investigate laboratory teaching practices within transnational engineering education contexts. This approach supports iterative refinement of educational interventions through cycles of design, implementation, observation, and evaluation in authentic learning environments.

The research focuses on civil and electronic engineering laboratory teaching delivered to undergraduate students in China. It examines how structured, concept-centred, and culturally responsive laboratory designs influence student engagement, participation, and conceptual learning in large-cohort practical settings.

Data were collected through facilitator reflections, student feedback, learning artefact review, and engagement observations, enabling triangulated evaluation of both pedagogical effectiveness and operational feasibility. While the study is grounded in implementation within Chinese TNE contexts, the findings are intended to inform future adaptation of scalable laboratory teaching approaches in other large-cohort engineering education settings.

A. *Participants and Settings*

The authors were directly involved in the design and delivery of the laboratory interventions as Irish lecturing staff operating within a transnational education (TNE) context. This positioned them as practitioner-researchers with embedded insight into both pedagogical design and implementation. Recognising the potential for reflexivity bias arising from this dual role, the study adopts a reflective stance, explicitly acknowledging how prior teaching experience, cultural background, and pedagogical assumptions may shape interpretation of observations and outcomes.

In China, participants included undergraduate students enrolled in the civil and electronic engineering degree courses at Henan Polytechnic University, Jiaozuo located in Henan province in China. For these courses, the practical laboratory modules for the electronic/computer and civil engineering modules saw typical lab classes of 100-125 students across first and second years of the course.

In Ireland, comparable computer science/electronic engineering degree courses would have undergraduate lecture cohorts of approximately 120 students, with lab class taking groups of 60 students. For civil engineering courses lecture cohorts would be approximately 40-50 students with lab cohorts of 20-25 students.

Facilitators in this study included the lead instructor (the authors) and local teaching assistants/technicians.

B. Lab Design Features

The programme comprised a suite of laboratory design strategies trialled across civil/electronic/computer engineering laboratory sessions in China. The key design elements included:

1. Structured Peer Collaboration: Students worked in small groups using internally assigned, role-based team structures, including roles such as facilitator, recorder, analyst, and quality checker. Roles rotated across laboratory sessions to encourage shared responsibility and exposure to multiple aspects of experimental practice.

2. Scaffolded Digital Lab Guides: Layered laboratory tasks and deliverables were developed for each session, including baseline, extension, and stretch activities. Scaffolded supports included conceptual prompts prior to procedural steps, just-in-time learning resources such as short instructional videos and annotated diagrams, and structured checklists.

As shown in Figure 1, a sample digital video guide illustrates content developed for electronic engineering laboratory. This type of scaffolding was designed to accommodate variations in students' prior knowledge and language proficiency. The structured guidance aimed to reduce cognitive load and allow students to focus on conceptual understanding rather than procedural uncertainty.

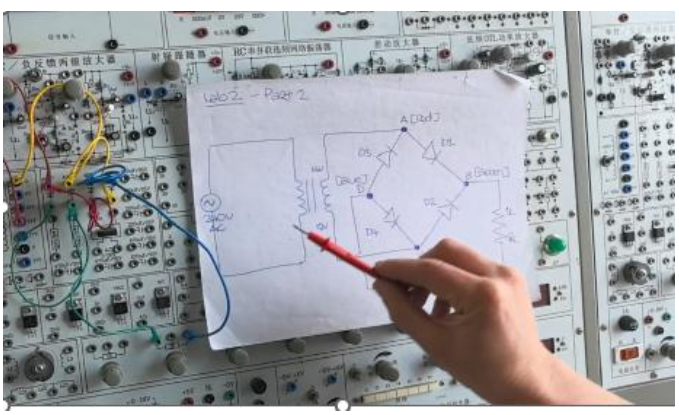
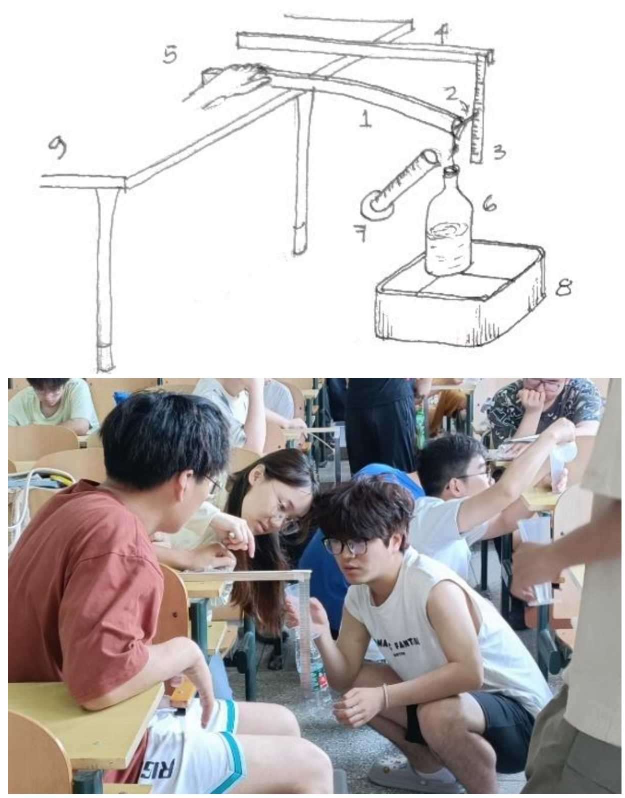


Figure 1. Example of scaffolded digital video guide used in an electronic engineering laboratory. The figure illustrates the use of layered instructional supports, including visual walkthroughs and annotated guidance, to support conceptual understanding and reduce cognitive load in large-cohort settings.

3. Formative Feedback Loops: Real-time feedback mechanisms were integrated into laboratory workflows through digital platforms such as Weixin/WeChat. These included low-stakes concept checks and short reflective prompts designed to monitor student progress and support incremental learning throughout the module.

4. Wellbeing and Inclusion Supports: Laboratory sessions incorporated predictable pacing, clearly visible milestones, and community-building activities. Group and forum discussions were facilitated through Weixin, supported by automated language translation functionality. Optional asynchronous walkthrough materials were also provided to support revision, catch-up learning, and flexible engagement.

5. Concept-Centred Framing: Practical, low-resource experimental activities were designed for the Civil Engineering course to focus on the development of conceptual comprehension. Three in-class experimental activities were developed with an example of one illustrated in Figure 2.



a)

b)

Figure 2. Low-cost cantilever beam experiment in civil engineering. (a) Schematic representation of the experimental setup; (b) students conducting the experiment in a classroom environment. The activity demonstrates elastic deformation, material behaviour, and structural response using accessible materials.

Concepts of elastic deformation, stress-strain behaviour, and material properties were introduced in this experiment through testing of timber cantilever beams. The specimens were fixed at one end and loaded incrementally using a simple water-based loading system, with deflection measured relative to a rigid reference. The use of low-cost materials ensured the activity could be easily implemented in typical classroom settings and exposed students to boundary conditions different from those commonly presented in lectures. Students recorded deflections under increasing load until failure occurred. Elastic stiffness and failure stress were calculated using fundamental beam theory. Repeated testing allowed students to observe variability in timber performance and consider its significance in structural design.

All figures have been prepared in high-resolution vector or raster format (minimum 300 dpi) to ensure clarity in both digital and print formats.

C. Characterisation

Baseline characterisation of the Chinese laboratory context involved documenting existing laboratory structures, available resources, and established student learning norms. The redesigned laboratory package was then implemented across multiple laboratory cycles, typically spanning four-week experimental modules.

Implementation followed an iterative design approach. Observational notes, facilitator reflections, and student interactions were reviewed throughout each cycle. Mid-cycle adjustments were made where necessary, including modifications to task scaffolding, pacing, and formative assessment checkpoints to address emerging learning challenges and operational constraints.

D. Review and Analysis

Evaluation of the practical laboratory sessions in China focused on both facilitator and student experiences. Data was gathered through brief in-lab reflective observations and structured field notes documenting engagement patterns, operational bottlenecks, and resource constraints. Learning artefacts including laboratory notebooks, digital submissions, and concept-check responses, were also analysed to inform the review process.

Additional insights into the electronic engineering laboratories were obtained through learning analytics, including usage logs associated with digital laboratory guides and walkthrough resources.

To mitigate potential researcher bias associated with the authors' dual instructional and evaluative roles, multiple strategies were employed. These included data triangulation across facilitator observations, student artefacts, and learning analytics; structured field-note protocols to reduce interpretive drift; and separation of roles during data collection activities where feasible. Reflective observations were documented contemporaneously and revisited during analysis to distinguish descriptive accounts from interpretive commentary.

Following completion of the civil engineering experimental module, a focus group was conducted with 5 volunteer students. The session was facilitated by an academic staff member independent of teaching and assessment activities, ensuring a degree of separation between participants and the instructional team. This approach was adopted to reduce social desirability bias and encourage more open reflection. The authors were not present during the focus group session, and responses were anonymised prior to analysis to further support ethical integrity and reduce potential influence arising from power dynamics. A semi-structured discussion format was employed, guided by prompt questions relating to student engagement, conceptual understanding of structural behaviour, comparisons with lecture-based instruction, and challenges encountered during the laboratory activities. The focus-group discussion was audio-recorded, transcribed, and anonymised prior to analysis. The transcript was reviewed repeatedly to identify recurring ideas and patterns. An inductive thematic analysis approach was employed, whereby responses were coded and grouped into broader themes relating to engagement, conceptual understanding, links between theory and practice, and perceptions of experimental variability. The identified themes were reviewed against the original transcript to ensure consistency of interpretation, and representative quotations were selected to illustrate key findings.

A semi-structured discussion explored student perceptions of engagement, conceptual understanding, comparisons with lecture-based instruction, and challenges encountered during the laboratory activities. Responses were anonymised and analysed using thematic analysis to identify recurring patterns and key themes.

Figures were designed to support interpretation of key pedagogical interventions and are described in sufficient detail to ensure accessibility for readers where visual inspection may be limited.

IV. Results and Discussion

Reflections from Irish lecturing staff (the authors), critically examined through a reflexive analytical lens, informed interpretation of transnational education (TNE) delivery in China focused on the design and facilitation of practical laboratory sessions in civil and computer/electronic engineering programmes. Across multiple delivery cycles, several consistent themes emerged relating to student engagement, instructional design, and scalability. Evidence from civil engineering student focus groups provided additional insight and triangulation of staff observations.

1. Cultural Framing and Participation: Irish staff observed that Chinese students' strong respect for authority and examination-oriented learning culture fostered high levels of diligence and procedural accuracy. However, these norms could reduce spontaneous questioning and risk-taking during laboratory sessions. Structured mechanisms for participation, including anonymous polling and rotating team roles, were found to broaden engagement while remaining culturally aligned with local expectations.

2. Structure, Predictability, and Cognitive Load: Scaffolded laboratory guides incorporating explicit milestones, checklists, and exemplar artefacts improved session flow and reduced operational bottlenecks. Time-boxed activities and visible "stop-check" gates reduced rework and strengthened safety compliance. This structured approach was particularly effective in managing large cohorts, enabling lecturers, facilitators, and technicians to support multiple teams simultaneously.

Students reported that the structured progression of laboratory activities reduced cognitive overload associated with unfamiliar experimental procedures. Several participants noted that stepwise guidance allowed them to focus on interpreting experimental outcomes rather than navigating instructions, thereby improving confidence and task efficiency.

3. Concept-First Sequencing and Experiential Understanding: Introducing laboratory sessions with short conceptual prompts, such as physical phenomena, failure modes, or anomalous data examples, helped students connect experimental measurements with theoretical models. In the Chinese context, this approach appeared to strengthen confidence prior to procedural tasks. In Ireland, similar sequencing has been used to reduce procedural imitation and promote deeper conceptual reasoning during post-laboratory reflection.

Student focus group responses strongly supported this observation. Participants reported that observing beam deflection and structural failure behaviour enhanced intuitive understanding of stiffness, flexural stress, and structural response. Students also emphasised that conducting material property testing prior to structural experiments clarified the relationship between material behaviour and structural performance. These findings highlight the importance of experiential sequencing in supporting conceptual integration.

4. Formative Micro-Assessments and Inclusive Learning: Embedding low-stakes formative checks, including short concept probes, minute papers, and peer teach-back activities, surfaced misunderstandings early and provided facilitators with rapid insight into student comprehension. These micro-assessments proved particularly valuable where language barriers or cultural hesitancy might otherwise mask confusion.

Students described these formative interactions as useful opportunities to verify understanding and compare interpretations within their groups. Variations in civil engineering experimental results between teams were frequently discussed during these activities, prompting reflection on fabrication quality, connection performance, and material variability. Such reflection challenged deterministic assumptions commonly associated with purely analytical learning approaches.

5. Structured Team Roles and Accountability: Role rotation among facilitator, recorder, analyst, and quality checker positions distributed participation more equitably and clarified group expectations. Staff observed improved traceability of decision-making processes within laboratory documentation and enhanced shared accountability for safety and quality assurance.

Table 1 summarises key observed contrasts between Chinese and Irish laboratory contexts, with Ireland serving as the baseline comparison. Differences were evident in classroom discourse patterns, assessment drivers, and support structures. Chinese laboratory sessions were characterised by high diligence and procedural accuracy, whereas Irish cohorts typically demonstrated more dialogic interaction but greater variation in prior knowledge and learning confidence.

Across both contexts, structured design elements including conceptual framing, layered scaffolding, collaborative roles, and formative micro-assessment supported engagement and conceptual development. However, effective implementation required contextual adaptation. Anonymous participation channels and structured collaboration proved particularly effective in the Chinese context.

TABLE I
SUMMARY OF COMPARISON BETWEEN CHINA AND IRELAND PRACTICAL ENGINEERING LAB SESSIONS

Dimension	China (Observed)	Ireland (Observed)	Implications
Classroom discourse	High diligence; lower spontaneous questioning	More dialogic; uneven prior knowledge	Use anonymous channels and role rotation in China; layered entry points and peer support in Ireland
Assessment drivers	Exam orientation; precision valued	Mixed drivers; project/process valued	Pair conceptual prompts with visible success criteria in both contexts
Scale & support	Larger sections manageable with strict structure	Larger diversity requires flexible scaffolds	Maintain structure; add branching tasks and optional walkthroughs in Ireland
Language & inclusion	Some language barriers; preference for predictability	Varied proficiency and confidence	Micro-assessments and multimodal resources in both contexts

Beyond student-facing design, technician–instructor coordination emerged as a critical enabling factor. Shared pre-briefings and operational checklists aligned safety protocols, resource allocation, and troubleshooting processes. This coordination was particularly important in large-scale laboratory delivery.

Short iterative feedback cycles also contributed significantly to laboratory refinement. Week-to-week adjustments informed by poll data, artefact review, and facilitator reflection produced measurable improvements in student engagement and workflow efficiency. Conceptual framing strategies were found to transfer effectively across cultural contexts when paired with concrete exemplars, such as signal noise interpretation or strain measurement anomalies.

The findings are practice-based and context-specific. Self-selection into feedback activities and variation in facilities and institutional resources may limit direct transferability. Nevertheless, triangulated qualitative evidence including student reflections, facilitator observations, and laboratory artefact quality, supports the robustness of the reported design patterns. Table II summarises the key design interventions alongside their observed impacts and supporting evidence, offering a consolidated view of findings across both contexts.

TABLE II
SUMMARY OF OBSERVED IMPACTS OF LABORATORY INTERVENTIONS

Design Element	Observed Impact	Evidence Source	Context
Structured peer collaboration (role rotation)	More balanced participation and improved accountability within teams	Facilitator observations; student feedback	China
Scaffolded digital lab guides	Reduced cognitive load and improved workflow efficiency	Student feedback; observational notes	China
Concept-first sequencing	Stronger linkage between theory and experimental observation	Student focus group responses	China / Ireland
Formative micro-assessments	Early identification of misunderstandings; improved conceptual clarity	Facilitator reflections; student discussion	China
Anonymous participation channels	Increased engagement from less vocal students	Observations; student interaction patterns	China
Layered task design (baseline–extension–stretch)	Supported diverse ability levels and pacing	Instructor reflections	Ireland
Multimodal supports and asynchronous resources	Improved accessibility and inclusion across cohorts	Usage patterns; facilitator feedback	China / Ireland

These findings can be conceptualised as an interaction between structured instructional design (scaffolding, roles, sequencing), participation mechanisms (feedback loops, anonymous engagement), and contextual factors (culture, cohort diversity), which together influence student engagement and conceptual learning outcomes in large-cohort laboratory environments.

Overall, the results suggest that structured (yet flexible) laboratory design can enhance conceptual understanding, promote inclusive participation, and support scalable engineering education across diverse cultural and institutional contexts.

V. CONCLUSIONS & FUTURE WORK

This study examined the implementation of redesigned civil and electronic engineering laboratory practices within a transnational education (TNE) context in China. The findings demonstrate that culturally responsive, concept-centred, and highly structured laboratory design can enhance student engagement, inclusivity, and conceptual learning in large-cohort engineering education.

The work highlights three principal outcomes. First, from a pedagogical perspective, concept-first laboratory sequencing supported stronger connections between theoretical knowledge and experimental evidence. By foregrounding observable engineering phenomena such as signal integrity, measurement uncertainty, and structural response, laboratory activities promoted analytical reasoning and reduced procedural “recipe-following” behaviours.

Second, structured laboratory scaffolding contributed significantly to operational effectiveness. Clearly defined milestones, shared assessment criteria, and coordinated technician–lecturer preparation improved workflow efficiency, reduced bottlenecks, and strengthened safety and quality assurance in high-capacity laboratory environments. These findings demonstrate the importance of combining pedagogical design with operational planning when scaling laboratory education.

Third, the integration of inclusive participation mechanisms broadened student engagement. Role rotation, anonymous participation channels, and multimodal digital supports provided multiple entry points for learners with diverse linguistic backgrounds and prior knowledge levels. Student feedback indicated that collaborative experimental tasks promoted peer learning and critical reflection, particularly when variations between experimental results prompted discussion of uncertainty and practical limitations in engineering systems.

The study also highlights the importance of contextual adaptation. While structured and highly scaffolded laboratory systems supported effective delivery within the Chinese context, their successful application requires sensitivity to institutional, cultural, and cohort-specific factors. The findings reinforce the view that TNE initiatives function most effectively as reciprocal learning environments, enabling bidirectional transfer and adaptation of teaching practices rather than one-directional pedagogical export.

The findings presented in this study offer a strong, practice-informed contribution to the design of large-cohort engineering laboratory education within transnational education (TNE) contexts. The study also highlights several important opportunities for further development and extension, particularly in relation to evaluation frameworks, scalability, and cross-context adaptation.

The work presented here is situated within a specific institutional partnership and cultural setting, namely undergraduate engineering programmes delivered at Henan Polytechnic University in Henan, China. This contextual grounding represents a key strength of the study, providing rich insight into authentic teaching and learning environments. This presents an opportunity in the future to extend and validate these findings across a broader range of institutional contexts. Future work can also include more systematic, cross-institutional studies to further explore how the identified design strategies translate across diverse educational systems.

The study adopts a design-based and practice-oriented methodology, drawing on triangulated qualitative evidence including facilitator reflections, structured observations, student feedback, and analysis of learning artefacts. This approach enables deep insight into pedagogical effectiveness and operational feasibility in real-world settings. Building on this, future research offers the opportunity to complement these findings with more formalised and quantitative evaluation frameworks. In particular, the development of structured assessment approaches within Irish engineering education contexts would enable more precise measurement of conceptual understanding, experimental reasoning, and skill development. Establishing baseline and post-intervention comparisons, alongside validated metrics, would further strengthen the evidence base and support comparative analysis across different laboratory models.

The integration of learning analytics in this study demonstrates the potential of data-informed approaches to enhance laboratory design and delivery. Current applications focused primarily on student engagement with scaffolded digital resources and usage patterns. This provides a valuable starting point for future expansion. There is significant scope to extend the use of learning analytics at scale, including the development of longitudinal tracking of student learning trajectories, identification of engagement patterns across multiple laboratory cycles, and integration with assessment and feedback data. Such approaches would support more predictive and adaptive models of instruction, enabling targeted intervention and more responsive teaching in large-cohort environments.

In addition, student feedback mechanisms, including focus groups and reflective activities, provided important insight into learner experience and supported the triangulation of findings. The voluntary nature of participation represents an opportunity to further broaden inclusion in future work, ensuring that a wider range of student perspectives are systematically captured. Expanding the diversity and representativeness of feedback data will enhance the robustness and inclusivity of future evaluations.

Looking forward, there is considerable potential to extend and refine the proposed laboratory design framework across a wider range of disciplines and institutional contexts. Future work will explore its application within Irish programmes characterised by greater heterogeneity in student preparedness, learning preferences, and language proficiency. This includes developing more differentiated scaffolded pathways, enhancing support for independent learning, and exploring student co-creation approaches in laboratory design and evaluation.

Finally, the transnational nature of this work offers ongoing opportunities for reciprocal learning and pedagogical innovation. The structured and concept-centred design approaches developed within the Chinese context provide a strong foundation for adaptation and enhancement within Irish and other international settings. Future research will continue to examine this bidirectional exchange, combining structured design, expanded evaluation metrics, and advanced learning analytics to support the development of scalable, inclusive, and evidence-informed engineering laboratory education.

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Supplementary Material A: Laboratory Design Patterns Checklist for Transnational Engineering Education

This supplementary material provides a practical checklist of key laboratory design patterns derived from the findings of this study. The checklist is intended to support educators and practitioners in implementing structured, scalable, and culturally responsive laboratory teaching approaches in transnational education (TNE) contexts.

The design patterns presented reflect recurring themes identified through iterative implementation, observation, and evaluation across civil and electronic engineering laboratory environments. They are not prescriptive but are intended as adaptable guidelines that can be tailored to different institutional, cultural, and cohort-specific settings.

By consolidating these patterns into a concise and actionable format, this checklist aims to bridge research and practice, enabling educators to translate evidence-informed strategies into effective laboratory design and delivery in diverse engineering education contexts.

TABLE A.I
LABORATORY DESIGN PATTERNS FOR TRANSNATIONAL ENGINEERING EDUCATION

Design Dimension	Design Pattern & Focus	Implementation Indicators
Instructional Structure	Scaffolded lab design (layered tasks: baseline–extension–stretch)	Sequential progression; clear milestones; structured workflows
Conceptual Framing	Concept-first sequencing (theory before procedure)	Use of prompts, phenomena, or real-world examples prior to experimentation
Collaboration	Role-based teamwork (rotating roles)	Defined roles; shared responsibility; balanced participation
Feedback	Formative micro-assessment (low-stakes checks)	Short quizzes, reflections, peer discussion during sessions
Engagement	Inclusive participation channels	Anonymous polling; digital or group-based responses
Cognitive Load	Structured guidance and simplification	Checklists, exemplars, and stepwise instructions provided
Digital Support	Scaffolded digital resources	Videos, annotated diagrams, asynchronous walkthroughs
Flexibility	Layered learning pathways	Optional extension tasks; self-paced support materials
Wellbeing & Inclusion	Predictable, supportive environment	Consistent structure; clear expectations and session pacing
Contextual Adaptation	Culturally responsive design	Alignment with student norms and participation behaviours
Evaluation	Iterative refinement cycles	Use of feedback, artefacts, and observations for redesign
Scalability	Large-cohort delivery design	Efficient coordination; manageable facilitation structures