WIP: Designing a Transformative International Research Experience: Integrating Institutional Collaboration, Immersions, and Reflective Practice

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Abstract

This program design paper presents the structure of a Transformative International Research Experience (TIRE) that conceptualizes global engineering education as a structured process of intercultural collaboration, research engagement, industrial exploration, and reflective transformation. Grounded in Transformative Learning Theory and Experiential Learning Theory, the model frames international research as an intentional pathway for developing globally engaged engineers. The program operates through multi-institutional partnerships in which jointly supervised, cross-institutional student teams address shared research priorities such as sustainability, digital innovation, and community resilience. Student learning is scaffolded through three forms of immersion (research, industrial, and cultural–historical) supported by pre-experience preparation and Individual Development Plans (IDPs). Weekly reflections aligned with Mezirow's Habits of Mind capture cognitive, affective, and perspective transformations during the experience. The paper concludes by discussing implementation challenges, mitigation strategies, and key IDP domains shaping students' developmental trajectories.

Keywords: Transformative Learning, Global Engineering Education, Habits of Mind, Institutional Collaboration, Intercultural Research Experience

1. Introduction

1.1. Overview

As engineering challenges become increasingly global, socio-technical, and interdisciplinary, international research experiences have emerged as essential components of contemporary engineering education. Such programs expose students to diverse research ecosystems, cultural contexts, and professional expectations, helping prepare them for careers that require intercultural collaboration, ethical judgment, and the ability to work across differences [1],[2]. This paper presents a theory-informed program design and implementation model for an international research experience.

Prior work has shown that global competency development is not an automatic outcome of international mobility; rather, it depends on structured learning environments that integrate preparation, mentoring, and reflective scaffolding [3],[4]. This gap between program intent and learning outcomes is particularly pronounced in Global North–Global South collaborations, where asymmetries in power, resources, and epistemic authority can limit reciprocity and student development [5],[6]. Aligning with this work, the Transformative International Research Experience (TIRE) model was developed to address these challenges and is being implemented through a National Science Foundation–funded International Research Experience for Students (NSF-IRES) program facilitated by a formal partnership between a U.S.-based institution (University of Cincinnati) and a Ghanaian institution (University of Cape Coast). Rather than treating international research as a peripheral enrichment activity, TIRE positions it as a designed

learning environment grounded in learning theory, equity, and intentional developmental scaffolding.

1.2. International Research Experiences in Engineering

International research experiences occupy a growing but still under-theorized space within global engineering education. Prior studies document benefits such as increased cultural awareness, professional confidence, and motivation to pursue globally oriented careers [1],[2]. However, these outcomes are highly variable and often depend more on program design than on destination alone.

Knight and colleagues demonstrate that global competency development requires curricular coherence, reflective integration, and opportunities to engage with socio-technical complexity [3],[7]. Without such structures, students often interpret international experiences through pre-existing technical or cultural frames, limiting deeper learning. Similarly, Davis and Sanderlin [8] argue that many international engineering programs lack alignment among learning objectives, experiential activities, and assessment, resulting in missed opportunities for professional formation.

Scholars further emphasize the importance of addressing host–visitor dynamics and power relations in transnational programs. Traditional study abroad literature often centers the experiences of visiting students while overlooking the agency and learning of host students and faculty [9],[10]. Decolonial critiques highlight the risk of extractive research practices in Global South contexts and call for reciprocal partnerships and shared ownership of knowledge production [5],[6]. The TIRE model responds directly to these critiques by integrating theory-driven reflection, co-mentorship, and institutional reciprocity into the design of international research experiences.

2. **Conceptual Framework**

The Transformative International Research Experience (TIRE) is grounded in a multi-theoretical framework that integrates Transformative Learning Theory and Experiential Learning Theory. Together, these perspectives illuminate how students from the University of Cincinnati (US) and the University of Cape Coast (Ghana) experience, interpret, and learn from international, interdisciplinary research collaborations. This integrated framework guides the design of the program's curriculum, mentoring structures, reflective activities, and evaluation strategies.

2.1 Transformative Learning Theory

Transformative Learning Theory (TLT) posits that profound learning occurs when individuals confront disorienting dilemmas, experiences that challenge taken-for-granted assumptions and require critical reflection to make meaning of new contexts. Through this process, learners undergo perspective transformation, developing more inclusive and integrative ways of understanding themselves and the world [11].

International research environments offer fertile ground for transformative learning. Students navigate unfamiliar cultural norms, scientific practices, institutional expectations, and interpersonal dynamics. Such experiences disrupt habitual ways of thinking and demand

reflective evaluation of values, beliefs, and cognitive frames. For students for the University of Cincinnati, cultural immersion in Ghana often introduces disorienting dilemmas related to communication practices, resource constraints, or culturally grounded approaches to research [12]. For students at the University of Cape Coast, collaborating with foreign peers can provoke reflection on identity, expertise, and asymmetries embedded in global STEM mobility. In TIRE, weekly reflective prompts aligned with Mezirow's phases of transformation encourage students to critically interrogate assumptions and document shifts in understanding.

2.2 Experiential Learning Theory

Experiential Learning Theory (ELT) conceptualizes learning as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation [13]. The TIRE model is intentionally structured to support continuous movement through this cycle across the research experience.

Students engage in concrete experiences through laboratory work, field visits, cultural–historical excursions, and industrial immersions. Weekly reflective writing tasks prompt reflective observation, encouraging students to examine emotions, challenges, and insights emerging from their experiences, complemented by feedback from faculty from the University of Cincinnati. Research seminars and mentor discussions facilitate abstract conceptualization, helping students connect observations to engineering theory, sustainability concepts, and intercultural frameworks. Iterative research design, data collection, and teamwork support active experimentation as students test and refine ideas within new cultural and environmental constraints. By intentionally structuring the program around Kolb's cycle, TIRE ensures that experiential learning is systematic and cumulative rather than incidental.

2.3 Host–Visitor Dynamics and Cultural Power Dimensions

A critical addition to the conceptual foundation of TIRE is explicit recognition of the host–visitor dynamic, which shapes learning, collaboration, and mentorship in transnational programs. Unlike traditional study abroad literature that focuses primarily on the experiences of students traveling outward [10],[14], the TIRE model acknowledges that students the University of Cincinnati function as visitors entering University of Cape Coast's academic, cultural, and social ecosystem, while students from the University of Cape Coast serve as hosts navigating both their own research development and expectations of contextual guidance.

This dynamic is influenced by cultural value patterns described in Hofstede's cultural dimensions, particularly Power Distance, Individualism–Collectivism, and Uncertainty Avoidance. Ghana's comparatively higher Power Distance often positions instructors and local mentors as authoritative knowledge holders, shaping collaboration and decision-making. The United States' higher Individualism aligns with University of Cincinnati students' expectations of autonomy and self-direction. By explicitly acknowledging these asymmetries, TIRE integrates training on cultural humility, role expectations, boundary setting, and equitable collaboration, aligning with decolonial critiques of global STEM education [5],[6].

3. Program Structure

The figure below (Figure 1) illustrates the integrated learning architecture of the Transformative International Research Experience (TIRE) model. The framework positions Kolb's experiential learning cycle, Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation, around the Student Researcher as the primary mechanism through which learning occurs. Research, industrial, and cultural immersions serve as sources of concrete experience that initiate iterative learning cycles. Structured reflection and goal integration mechanisms, including weekly guided reflections and the Individual Development Plan (IDP), scaffold reflective observation and conceptualization. Through repeated experiential cycles, learners may progress along Mezirow's transformative learning trajectory, from disorienting dilemmas to action planning, resulting in the development of globally engaged, self-aware engineering professionals. Faculty mentor acts as a facilitator throughout the process. Details are presented in the subsections below.

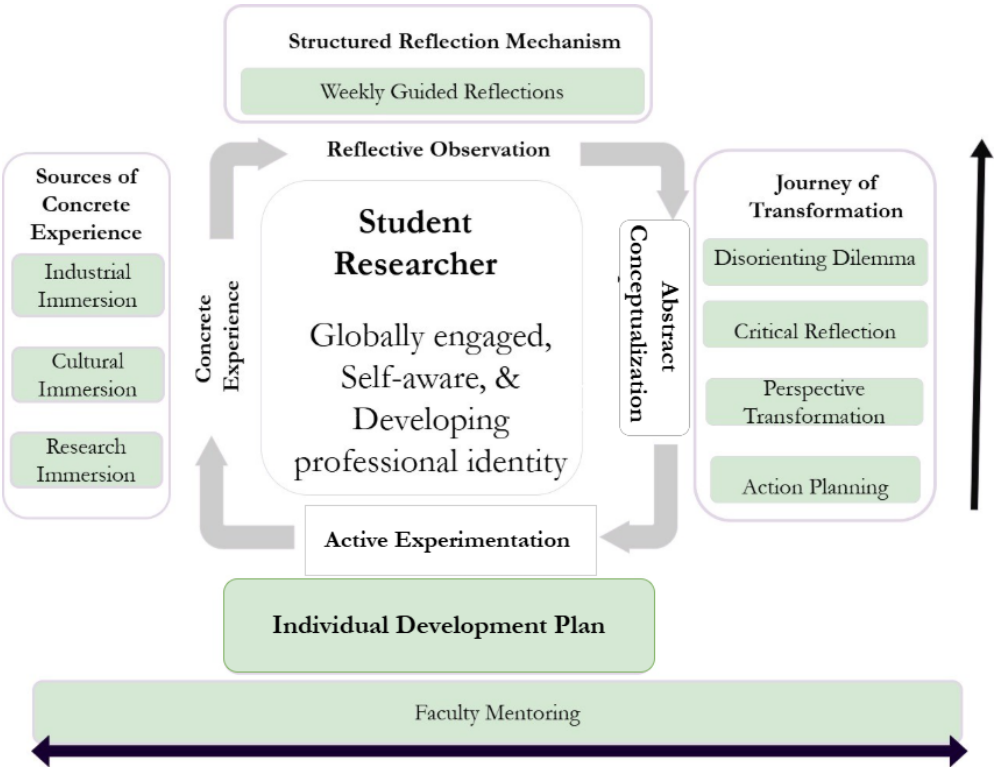

Figure 1: Integrated Experiential–Transformative Learning Framework of the TIRE Model

3.1 Preparatory Curriculum and Individual Development Plans (IDPs)

The preparatory phase of the TIRE program is designed to ensure that students from the University of Cincinnati and the University of Cape Coast begin the international research experience with shared expectations, foundational knowledge, and clearly articulated developmental goals. Grounded in the program's conceptual framework, the preparatory curriculum emphasizes intercultural awareness, ethical research practices, reflective readiness,

and intentional goal-setting, elements consistently identified as critical to effective international and experiential learning [1],[7]. Central to this process is the Individual Development Plan (IDP**)**, which provides a structured method for aligning students' personal aspirations with the academic, professional, and collaborative objectives of the program (National Academies of Sciences, Engineering, and Medicine (NASEM) [15].

3.2 Pre-Experience Module

The pre-departure module provides a structured learning environment that prepares students for the intellectual, interpersonal, and ethical complexities of conducting collaborative research in an international setting. The curriculum includes a sequence of workshops that introduce core concepts in research ethics, intercultural communication, safety and risk management, mental health and resilience, and the social dynamics of power, privilege, and host–visitor relationships. Together, these sessions equip students with the tools needed to navigate both the technical and socio-cultural dimensions of the upcoming experience, aligning with prior research emphasizing preparation as a prerequisite for meaningful global learning [1],[4].

Pedagogically, the pre-departure curriculum uses interactive workshops, case studies, and scenario-based exercises designed to simulate challenges commonly encountered in cross-cultural, interdisciplinary research. Case-based discussions on communication breakdowns, ethical dilemmas, and differing academic expectations allow students to interrogate assumptions and anticipate potential areas of misunderstanding. Scenario-based exercises involving role-play help students practice perspective-taking, negotiation, and conflict resolution. These learning activities are intentionally aligned with habits of mind such as empathy, flexibility, and metacognition, and with the reflective demands embedded in Transformative Learning Theory and Experiential Learning Theory, ensuring that the preparatory curriculum functions as the first phase of transformative, experiential learning [11],[14].

3.3 Individual Development Plans (IDPs): Structure and Developmental Domains

The Individual Development Plan is a central pedagogical tool in the TIRE program, designed to help students articulate goals and align them with the program's broader research and developmental objectives. Drawing inspiration from graduate-level IDP models but adapted for undergraduate research and intercultural engagement, the TIRE IDP facilitates intentional planning across five developmental domains [15]:

- Personal and Cultural Development focuses on how students anticipate navigating cultural differences, identity, communication norms, and adaptation in unfamiliar contexts. This domain aligns with ABET Student Outcome 4 (ethical and professional responsibility) and Outcome 5 (effective communication with diverse audiences).

- Academic and Professional Growth captures students' intended skill development, learning goals, and connections between the experience and their academic or early career trajectories. This domain aligns with ABET Outcome 1 (solving complex engineering problems) and Outcome 7 (acquisition of new knowledge and lifelong learning).

- Personal Well-Being and Health addresses strategies students anticipate using to manage stress, regulate emotions, and build resilience during the experience. Although not explicitly named in ABET criteria, this domain underpins students' capacity to engage effectively in complex problem solving, teamwork, and ethical judgment, supporting sustained performance across Outcomes 1 and 4 [16].

- Personal and Social Relationships examines expectations related to teamwork, peer interaction, mentorship, and relationship-building across cultural and disciplinary boundaries. This domain aligns with ABET Outcome 5 and supports collaborative competencies emphasized in engineering education literature [17].

- Long-Term Career and Life Goals focuses on how students situate the experience within broader aspirations, including career direction, professional purpose, and life planning. This domain aligns most directly with ABET Outcome 7 while also supporting Outcome 4 by foregrounding intentional decision-making informed by societal responsibility and personal values.

Students complete the IDP prior to regrouping in Ghana through a structured sequence of reflective prompts that guide articulation of values, anticipated challenges, and actionable strategies for success. Informed by Transformative Learning Theory and the Habits of Mind framework, these prompts emphasize critical reflection, goal-setting, and self-regulation, encouraging students to consider how assumptions, identities, and learning dispositions may shift during the experience [11],[18].

3.4 Research Immersion

The research immersion engages participants in faculty-mentored projects that focus on affordable, low-cost, and contextually appropriate solutions for sustainable living in tropical environments. Research themes include sustainable food production systems, environmental remediation, and data-driven tools to support agricultural equity. Through hands-on research conducted in real-world settings, participants develop technical expertise while gaining a deep understanding of the social, environmental, and economic contexts in which sustainable solutions must operate.

Collectively, the research immersion advances knowledge generation in sustainability science while strengthening international collaboration and reinforcing U.S. leadership in science and engineering through globally engaged research and workforce development.

3.5 Cultural Immersive

To situate technical research within its social, historical, and cultural context, participants engage in weekly cultural immersion experiences. These activities are intentionally designed to include both visiting and host-country students, expanding access to cultural sites that many participants might not otherwise experience.

Planned activities include visits to major touristic and historical attractions to include Cape Coast Castle, the Kakum National Park, sessions of Cultural Dance and Culinary Classes, the Fetu Afahye and Odwira Festivals (Cape Coast), Kwame Nkrumah Mausoleum and Memorial Park;

Accra Arts Centre (Accra), Manhyia Palace, Bonwire Kente Weaving Centre (Kumasi), and Nzulezu Stilt Settlement and coastal environments (Takoredi). These experiences deepen contextual understanding, intercultural competence, and ethical awareness, reinforcing culturally responsive approaches to sustainability research.

3.6 Industrial Immersion

Participants further engage in bi-weekly industrial immersion visits that connect academic research to real-world practice. These visits expose students to industry-scale sustainability challenges, regulatory environments, and operational constraints.

Planned industrial visits include industry with long tradition of supporting students immersion into professional world in Ghana: Sika Chemicals Ghana Ltd. (Accra), Chocolate Factory and Cocoa Farm (outside Accra), Ghana Water Company (Cape Coast), Zeal Environmental Technologies Limited (Takoradi).

Together, the research, cultural, and industrial immersion components form an integrated learning system that prepares participants to address sustainability challenges in tropical contexts through technically rigorous, culturally grounded, and socially responsible solutions.

3.7 Weekly Reflection System

Each week, students complete a structured reflection survey that begins with affective grounding, summarizing the week in three words and recounting its high and low points. Samples reflection prompts are presented in Table 1. These narrative entries surface emotions, emerging tensions, and early indicators of learning or discomfort, consistent with prior work highlighting the role of affect in experiential learning [19]. Students then evaluate the impact of weekly experiences guided by the Mezirow six dimensions of Habits of mind: epistemic, sociolinguistic, psychological, moral–ethical, philosophical, and aesthetic [11]. For each dimension, students identify experiences contributing to change—research activities, collaboration, cultural immersion, mentor feedback, stress management, or unexpected events. This structure aims to captures the full experiential cycle of experience, reflection, conceptual meaning-making, and adaptation [13]. Early reflections (Weeks 1–2) emphasize orientation and adjustment; middle weeks (Weeks 3–6) focus on teamwork, communication, resilience, and societal context; later reflections (Week 7) prompt examination of emerging habits of mind such as persistence, empathy, flexibility, creativity, and metacognition. The final week emphasizes synthesis, asking students to articulate key lessons learned, evolving career trajectories, and the sustainability of relationships and skills developed. This scaffolded sequence aims to ensures reflection progresses from descriptive reaction to analytical interpretation and ultimately to transformative meaning-making [18].

Table 1: Sample reflection prompts

Reflection Prompt	Habits of Mind Targeted	Mezirow Dimension	Assessment Purpose	Data Source
Describe a moment during this week when your assumptions about research	Open-mindedness, Critical Thinking	Disorienting Dilemma	Identify triggers for perspective questioning	Weekly Reflection

practice were challenged. What caused this shift?				
How did working with international teammates influence how you approached problem-solving this week?	Empathy, Flexibility	Critical Reflection on Assumptions	Examine intercultural collaboration dynamics	Weekly Reflection
Describe a situation in which communication across cultures required you to adapt your behavior or expectations.	Empathy, Persistence	Meaning Perspective Examination	Capture affective and behavioral adaptation	Weekly Reflection
What connections did you make between your research activities and the local cultural or industrial context?	Systems Thinking, Curiosity	Contextual Reframing	Assess integration of technical and cultural knowledge	Weekly Reflection
Identify one challenge that caused discomfort or uncertainty. How did you respond, and what did you learn?	Resilience, Self-awareness	Emotional Processing	Document affective dimensions of learning	Weekly Reflection
How has this experience influenced your understanding of your role as a future engineer or researcher?	Self-direction, Ethical Reasoning	Perspective Transformation	Track professional identity development	Weekly Reflection
What changes, if any, are you making to your research approach or personal goals as a result of this experience?	Adaptability, Goal Orientation	Action Planning	Capture movement toward transformative action	Weekly Reflection
Reflect on progress toward the goals outlined in your Individual Development Plan. What adjustments are needed?	Metacognition, Responsibility	Reintegration	Link transformation to future planning	IDP Check-in

Discussion And Conclusion

This study presents how the Transformative International Research Experience (TIRE) operationalizes Transformative Learning Theory**,** and Experiential Learning Theory as interlocking design. Transformative learning is intentionally structured disorienting experiences, intercultural collaboration, open-ended research, and professional immersion, paired with scaffolded reflection that supports progression from descriptive to premise-level reflection. Habits of mind provide analytic domains through which students articulate changes in epistemic beliefs, identity, values, and meaning-making, while experiential learning structures the cyclical movement between experience, reflection, conceptualization, and experimentation. Together, these theories are embedded directly into program design via preparatory curricula, IDPs,

mentorship structures, and weekly reflection, enabling learning processes that are visible, assessable, and developmentally sequenced.

The TIRE model also addresses long-standing concerns related to equity, reciprocity, and host–visitor dynamics in international research and study abroad. By positioning partner institutions as co-designers and co-mentors rather than merely hosts of visiting students, TIRE disrupts hierarchical knowledge flows that often characterize Global North–Global South collaborations. Explicit attention to host–visitor roles, cultural power dimensions, and shared responsibility for learning creates conditions for reciprocal development among both visiting and host students. These design choices move beyond deficit-based or extractive models of international engagement and instead foreground relational, ethical, and contextual dimensions of global engineering practice.

Future work will focus on empirical evaluation of TIRE across cohorts and contexts, including longitudinal tracking and comparative studies. As engineering practice becomes increasingly global and socio-technical, the TIRE model offers a replicable framework for aligning international research experiences with the broader goals of engineering formation.

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