

How Blended Work-integrated Learning Fosters Students' Creative Design Competencies

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Abstract: Grounded in boundary crossing theory, we developed and examined a Blended Work-Integrated Learning (B-WIL) framework. Guided by an action research design, this study implemented the model in an undergraduate toy design course characterised by a blended ecology, dual-scale mentorship, and student-centred education. Operating as a critical “boundary broker,” the local mentor translated high-level global insights into the material realities of physical practice. 28 group reflection reports were collected and analysed through a dual-track qualitative strategy: (1) deductive process tracing of design episodes and (2) inductive thematic analysis of perceived competency development. Findings suggest that students encountered recurring challenges, including contextual dissonance, interpretive disconnects, prototype failures, and design fixation, yet resolved them through evolving patterns of support-seeking, experimentation, and cross-boundary communication. The local broker emerged as a key figure in mediating cultural misunderstandings, reframing global critiques, and validating physical prototypes that remote experts could not directly assess. Across the two project cycles, students demonstrated a marked behavioural shift: from epistemic dependence on expert authority towards autonomous, peer-driven experimentation and earlier engagement with material prototyping. The thematic analysis points to three emergent trans-boundary competencies cultivated through the B-WIL environment: sociomaterial fluency, contextual agility, and cross-boundary communication. These competencies equip students to navigate the digital-physical divide, reconcile local cultural identity with global market expectations, and synthesise complex knowledge across spatial and disciplinary boundaries. The study concludes that the B-WIL framework reframes the disembodiment risk of virtual WIL as productive boundary friction that accelerates professional growth. It also offers an actionable, scalable blueprint for institutions seeking to integrate global virtual networks with local physical mentorship, helping students remain materially grounded while becoming globally fluent.

Keywords: Blended learning, Work-integrated learning, Boundary crossing, Creative design education, e-Learning

1. Introduction

In the contemporary landscape of higher education, Work-Integrated Learning (WIL) has emerged not only as an employability add-on but as a leading pedagogical strategy that bridges academic theory and workplace practice (Curto-Reverte et al., 2025). Defined as a pedagogical approach that intentionally integrates theoretical learning with workplace practice, WIL engages three interconnected stakeholders: students, educational institutions, and external industry partners (Zegwaard and Pretti, 2023). Within this tripartite ecosystem, industry partners become active co-educators, working closely with academic instructors to co-design, co-deliver, and co-assess curriculum content (Ferns, Russell and Kay, 2016). This collaboration fosters a learner-centred environment in which educators transition from knowledge transmitters to facilitators of experiential learning, guiding students through authentic problem-solving and reflective practice.

This pedagogical shift is driven by accumulating empirical evidence that underscores the transformative potential of WIL. For students, it is a critical mechanism for enhancing work readiness, strengthening professional identity (Bowen, 2016; Bowen, 2020), and nurturing the self-regulation required for career development (Ramji et al., 2021; Ruskin and Bilous, 2021). For institutions and industry, it creates a symbiotic pipeline in which employers gain access to fresh perspectives and a broader talent pool, while universities innovate their pedagogical strategies to align with evolving market demands (Stirling et al., 2024). In the specific context of design education, where “learning by doing” and project-based inquiry are paramount (Martins et al., 2024), WIL is particularly vital. Design knowledge is inherently “situated” and “tacit,” involving material nuances and social negotiations that are difficult to simulate within school settings (Gero and Kannengiesser, 2004; Schön, 1983). Consequently, WIL has become an essential curricular component in leading design schools,

serving as the primary vehicle for fostering the epistemic fluency required to navigate complex professional environments.

To remain relevant in an increasingly globalised economy, WIL programs are shifting from traditional co-located to digitally mediated formats. Virtual WIL aims to overcome geographical constraints, offering students flexible access to global markets and international expertise. However, this digital shift creates a critical tension between the “global” and the “situated” (Thomas et al., 2010). While virtual models successfully expand reach, studies have highlighted a decline in depth, often characterised by “disembodied” learning approaches and a sense of disconnect among stakeholders (Yoon, 2020). In design, where physical engagement with materials and co-located mentorship are indispensable for tacit knowledge transfer, remote interactions often fail to provide the necessary “grounding” (Mok and Oehlberg, 2017). This creates a paradox: the traditional WIL modality offers deep mentorship but limited reach, while virtual models offer global reach but limited embodied learning.

This issue reveals a significant gap in the WIL literature on how to reconcile these competing demands, particularly in practice-based disciplines reliant on tacit knowledge transfer, such as design, engineering, business and clinical healthcare. Current pedagogical frameworks typically frame WIL as an ‘either-or’ proposition and fail to provide structured models that integrate global connectivity with the embodied, co-located mentorship it requires. This study addresses this critical gap by proposing a novel Blended Work-Integrated Learning (B-WIL) framework designed to bridge the “disembodiment” inherent in virtual models. It fills the void at the curriculum level through two key mechanisms. First, it employs physical-digital integration to create a blended ecology in which physical studio practice and digital global collaboration form a continuous workflow. Second, and crucially, it establishes a dual-scale mentorship by involving a local industry partner as a “boundary broker.” We draw upon Wenger’s (1998) Communities of Practice framework, specifically the mechanisms of “boundary crossing” and “brokering.” From this theoretical perspective, a broker is an actor who maintains multi-membership across multiple communities. In this study, the global virtual industry and the localised physical studio are connected by the broker, who facilitates the translation, coordination, and alignment of knowledge between them (Wenger, 1998; Akkerman and Bakker, 2011).

This model was implemented and evaluated through an action research approach over two semesters in an elective Toy Design course. This domain was selected as an ideal testbed because toy design uniquely demands both physical rigour (safety, mechanics, touch, etc.) and global market awareness. The course operated in partnership with a leading multinational children’s entertainment company, engaging professional inventors from the company’s North American headquarters (global experts) and its Hong Kong branch (local brokers) as co-teaching fellows. We evaluated the influence of B-WIL on students’ learning experience, specifically focusing on how they navigate distinct challenges during design teamwork and develop “trans-boundary” capabilities. Rather than merely assessing students’ perceptions, we seek to unpack the processual dynamics of students’ collaborative learning behaviours. Specifically, we examine how the B-WIL model reconfigures the problem-solving strategies of design students and how the “local industry broker” mediates interactions between global expertise and local practice to alleviate digital “disembodiment”. This research moves from conceptual proposition to an actionable strategy, providing institutions and educators with a tested model for modernising practice-based education. This work also ensures that students are not passive participants in disembodied digital learning but are fully equipped to navigate a globalised economy without sacrificing the situated, tacit mastery skills essential to practice.

2. Theoretical Background

2.1 The Shifting Landscape of WIL: From Situated Practice to Digitally Mediated

Work-Integrated Learning (WIL) is grounded in situated learning (Lave and Wenger, 1991), which posits that learning is not merely the cognitive acquisition of facts but a social process of entering a “community of practice.” In this view, the workplace is an epistemic environment in which students engage in legitimate peripheral participation (LPP). They begin at the periphery of professional practice and move towards the centre not only by completing tasks but by becoming enculturated into the profession.

In traditional, co-located WIL placements, this learning unfolds through two distinct yet intertwined channels. First, students receive explicit instruction in practical procedures and deliverables. Second, they passively absorb tacit knowledge, the “unwritten rules” of the profession that are rarely codified in textbooks. Through immersive collaboration with industry stakeholders, students grasp subtle workplace cultural norms by observing how professionals negotiate conflict, solve problems, manage time, and navigate hierarchy (Fleming and Haigh, 2018). This process is deeply embodied; students learn by mimicking the bodily gestures and professional

demeanour of their mentors, acquiring a “feel” for the game that can only be transmitted through sustained, face-to-face observation (Polanyi, 1966).

However, driven by evolving expectations for educational technology and the lasting impacts of the post-pandemic educational landscape, emerging WIL models have increasingly shifted towards flexible, digitally mediated formats. Virtual and hybrid WIL models are consistently praised for their logistical scalability, their capacity to expand global reach, and their ability to foster interdisciplinary connectivity across borders (Lewis and Burley, 2024; Linder, 2017; Zegwaard and Pretti, 2023). They provide unprecedented access to international expertise that traditional, localised placements cannot match.

Conversely, a critical examination of this recent literature reveals significant pedagogical limitations. While virtual platforms excel at transmitting explicit knowledge and managing tasks, they systematically struggle to facilitate the transfer of tacit knowledge. Recent empirical evaluations of hybrid work models show that the passive absorption of professional culture depends heavily on spontaneous communication, serendipitous interaction, and shared physical contexts, elements that purely virtual environments fail to reproduce adequately. Critics argue that existing fully remote and hybrid frameworks risk creating “disembodied” environments (Apostolidou, 2022), in which students acquire professional knowledge yet remain isolated from its underlying culture. Building on this, recent studies in transdisciplinary WIL (TWIL) emphasise that the psychological safety and “visceral” grounding required to navigate complex, ambiguous design problems require dedicated physical learning spaces (Jackson, Lambert and Coetzee, 2026).

This “mimetic difficulty” introduces significant pedagogical complexity. Confronted with a paucity of instructional models, educators report struggling to sustain student motivation or simulate authentic organisational learning in the absence of in-person, sociomaterial cues (Bell et al., 2022). The virtual models inadvertently create a “contextual gap”, stripping away the embodied, localised scaffolding essential to deep professional enculturation. Consequently, advanced frameworks are urgently needed that do not merely digitise work tasks but intentionally synthesise the expansive reach of global virtual networks with the indispensable, situated materiality of physical practice.

2.2 WIL in Design Education

Design education has long embraced problem- and project-based learning (PBL) as a pedagogical cornerstone. Rooted in progressive education theory, PBL prioritises learning through reflective practice (Dewey, 1938; Schön, 1983). By engaging students in an immersive, experiential learning process, it fosters student agency, self-regulation, and transferable skills (Norman and Schmidt, 2016). These qualities of PBL resonate with the principles of WIL, which emphasise engagement with authentic challenges and the transformation of academic knowledge into workplace practices through industry collaboration. However, a key disparity between PBL and WIL lies in how each restricts the “problem”, positioning WIL as PBL’s advanced extension.

Dorst (2006) contended that design problems are inherently ill-structured and paradoxical, requiring iterative, situated problem-solving approaches. However, within PBL, the “real-world problem” remains a “design problem”. Students are permitted to explore idealised conceptual solutions within a less-restricted design space. In contrast, WIL’s “authentic task” epitomises Dorst’s “design paradox”, demanding not only problem-solving proficiency but also the capacity to navigate ambiguity and reconcile conflicts inherent in professional practice. For instance, in the WIL project partnering with a toy manufacturer, students might grapple with reconciling safety regulations, the customer’s preference, and creative play mechanics. This distinction underscores WIL’s unique value in bridging academic idealism and industrial pragmatism in design education. It engages novice designers in the complexities of stakeholder demands, resource constraints, and cultural contradictions.

Moreover, design activity is inherently “sociomaterial.” Drawing on the theory of sociomateriality (Orlikowski, 2007), design practice is not merely a cognitive activity occurring in the designer’s mind, but an entangled performance involving materials, tools, and bodies. As Schön (1983) famously described, the designer engages in a “conversation with the situation,” where the material itself “talks back,” shaping the design trajectory. This material agency is particularly critical in domains such as ‘toy design’, where the success of an artefact relies heavily on tactile affordances, safety, ergonomics, and haptic engagement. A toy cannot be fully validated through visual representation alone; its ‘playability’ must be felt. When global industry experts are mediated solely through a screen, the sociomaterial feedback loop is severed. The expert can critique visual aesthetics, or the creativity and reliability of the idea yet cannot assess the embodied reality of the physical prototype (Mok and Oehlberg, 2017). The learning environment, therefore, should allow students to navigate the “digital abstraction” of global feedback while remaining grounded in the “material friction” of the local workshop.

2.3 The Blended WIL Framework

By synthesising the need for global market exposure with the necessity of situated materiality, this study proposes a Blended Work-Integrated Learning (B-WIL) framework. This framework operates on a dual-scale mentorship logic, designed to bridge the gap between international expertise and concrete situated practice. Central to this framework is the theoretical concept of boundary crossing (Akkerman and Bakker, 2011). “Crossing boundaries” addresses the professional imperative to venture into unfamiliar territory, requiring the negotiation and integration of complex information across disparate disciplines. In real-world practice, the capacity for such boundary work is increasingly regarded as paramount to domain-specific specialisation. This ability is particularly salient within the design professions, as Inns’s (2013) framework identifies. The emerging roles of modern designers are characterised by active boundary crossing across distinct epistemic realms. A boundary often manifests as a “discontinuity in action or interaction,” typically stemming from socio-cultural differences. Crucially, this discontinuity is further exacerbated by the mediated nature of virtual learning, which strips away the tacit sociomaterial cues of the physical classroom and creates a “contextual gap” that students often struggle to navigate (Ismail & Sabrina, 2023).

Therefore, the B-WIL framework positions the local industry partner as a “boundary broker” (Kubiak et al., 2014) operating at the intersection of two communities of practice: the global expert network and the local, physically situated student studio. This broker actively facilitates the dialogical learning mechanisms inherent in boundary crossing, specifically coordination and translation (Akkerman and Bakker, 2011). By interpreting divergent perspectives, the broker translates abstract, disembodied global feedback into concrete, materially grounded actions, enabling students to navigate the contextual gap. To sustain this complex brokering, the framework establishes a “blended ecology” as its foundational pedagogical space. Drawing on the concept of learning ecologies, this ecology is not merely an aggregation of digital platforms and physical desks; rather, it is theorised as a unified, hybrid environment in which the digital affordances of global connectivity are continuously integrated with the sociomaterial realities of local design collaboration.

As illustrated in figure 1, the model comprises three core components: 1) blended learning environments; 2) dual-scale industry participation (global and local); and 3) student-centred education. The dual-scale mentorship operates through an interdependent mechanism. Global industry experts introduce high-level, cutting-edge market insights and international design expectations, typically delivered through virtual engagements. However, because this global feedback can be disconnected from the students' material reality, the local mentors activate to ground these insights. Working directly alongside students during their collaborative design process, the local mentor translates the global directives into tangible, localised actions. They coordinate the physical execution of the project, ensuring the knowledge provided by the global network is actively materialised through situated design practices. Together, the two scales form a continuous, complementary loop: the global scale sets the international benchmark and provides high-level critiques, while the local scale provides the embodied, co-located scaffolding necessary to translate and achieve those benchmarks on the ground. This involves two distinct pedagogical mechanisms:

1. *Translation*: The broker decodes the abstract, high-level feedback from the global expert (e.g., market trends, brand values, innovations) into actionable, concrete instructions for the students (e.g., specific prototyping, testing and adjustments).
2. *Alignment*: The broker helps students “align” their localised ideas with global overview, filtering out “culturally illegible” concepts while preserving unique regional identities.

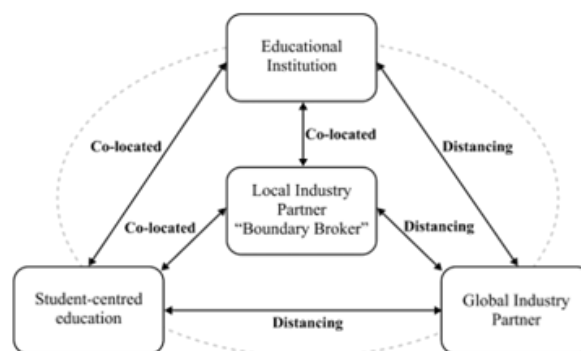


Figure 1: Blended WIL model (B-WIL) involving four stakeholders: students, educational institution, global industry partner and the local industry broker

Having established the theoretical architecture of the B-WIL framework and defined the mediating function of the boundary broker, it is necessary to empirically examine how this conceptual model operates in practice. By utilising a project-based design curriculum as our primary evaluative testbed, the current research seeks to address the following questions:

RQ1: How does the B-WIL influence students' learning experience and foster the development of specific "trans-boundary" capabilities during design teamwork?

RQ2: What are the processual dynamics through which the B-WIL reconfigures the problem-solving strategies of students engaged in collaborative learning?

RQ3: In what ways does the "boundary broker" mediate interactions between global perspectives and local practice to alleviate the "disembodiment" inherent in a digitally mediated learning environment?

3. Research Methodology

3.1 Action Research Cycle

This study employs the action research cycle (Carr and Kemmis, 1986) to guide curriculum design, implementation and evaluation, given the study's primary objective was explicitly interventional. This study requires an operational framework to actively introduce a boundary broker and objectively evaluate its impact on students' collaborative learning experience and problem-solving strategies. Action research has evolved into a methodical and iterative process in which researchers engage in self-evaluation, analysis and the construction of new knowledge in a participative and reflective manner. In action research, the researcher is embedded within the study context, usually assuming dual roles: as the creator of a pedagogical model and as a practitioner applying it in teaching practice. The holistic process includes four primary stages: action plan, implementation, evaluation and reflection (see Figure 2). This study has completed the first cycle, beginning with problem identification and concluding with a preliminary reflection on a two-semester pilot curriculum. The following subsections elaborate on the detailed actions carried out at each stage.

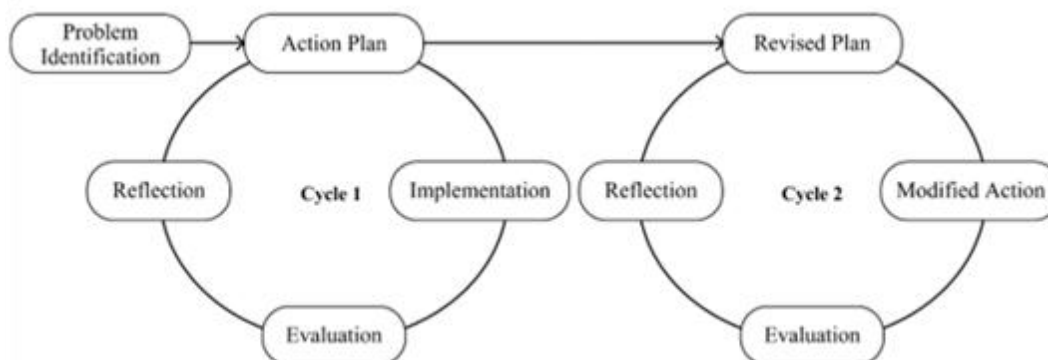


Figure 2: Action Research Cycle (Carr & Kemmis, 1986)

3.2 Participants

The WIL programme requires collaboration among three core stakeholder groups: students, the educational institution, and industry partners. After obtaining approval from the Institutional Review Board at The Hong Kong Polytechnic University (PolyU), we recruited 44 second- and third-year undergraduate students enrolled in the elective toy design course. Participation was entirely voluntary, and students were explicitly informed that their decision to participate or withdraw at any time would not affect their academic standing or final grades. We ensured anonymity, and only the course instructor, industry representatives, and research assistants had access to participants' design assignments and reflection reports. All relevant documents will be stored on the password-protected institutional server for three years.

Industry participation comprised two seasoned toy design experts from the company's global headquarters, complemented by two senior technicians from its Hong Kong branch. A PolyU Design faculty member led academic oversight as both principal investigator and course instructor, drawing on extensive expertise in design education and research. Two professionally trained research assistants supported the teaching and research process by coordinating stakeholder interactions and managing data collection and analysis. This tripartite structure ensured robust integration of theoretical rigour, industry relevance, and experiential learning, with

roles dynamically adapted across research stages (see Table 1). All industry stakeholders received clear instructions on research aims and procedures, and written consent confirming their voluntary participation was obtained before the course commenced.

The student cohort (N=44) consisted predominantly of product design majors (n=36), with the remainder majoring in communication design (n=5) and interaction design (n=3). A total of 21 students participated in the first semester, and 23 students participated in the second. They were randomly assigned to 7 groups and collaborated on two group projects each semester.

Table 1: Involving Participants at Distinct Research Stages

Stages	Participants
Problem identification	Educational supervisor (researcher); Toy design experts; Design technicians from local branch; Research assistants
Action Plan	Educational supervisor; Toy design experts; Design technicians from local branch; Research assistants
Implementation	Students; Educational supervisor; Toy design experts; Design technicians from local branch; Research assistants (observer)
Evaluation	Educational supervisor (Researcher); Toy design experts; Research assistants
Reflection	Educational supervisor (Researcher); Research assistants

3.3 Action Plan

The proposed B-WIL model applied in this curriculum combines co-located and online environments to foster a dynamic, learner-centred learning experience (see figure 3). Toy design experts from industry partners and product design supervisors from PolyU Design delivered lectures and seminars covering the histories and cultures of play; the design principles of toy invention; materials and manufacturing; market research for toys, games, and interactive experiences; and product commercialisation. Co-located tutorials, led by professional design engineers from the Hong Kong branch and PolyU mentors, provide hands-on technical guidance and conceptual support, ensuring students bridge theory and practice.

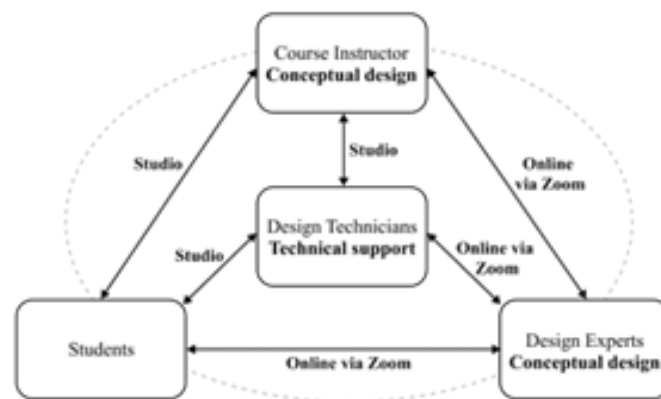


Figure 3: Application of B-WIL Framework at The Curriculum Level

The draft curriculum plan, encompassing course objectives, the integration of resources from both the university and the enterprise, and a meticulously designed syllabus, is collaboratively discussed and formulated by the educational instructor and industry representatives. This process occurs through a series of online and offline seminars until the plan is deemed ready and receives formal approval. Figure 4 illustrates the course's key teaching objective, which aims to guide students in producing high-fidelity design outputs with support from professional toy inventors for commercialisation in the global toy market.

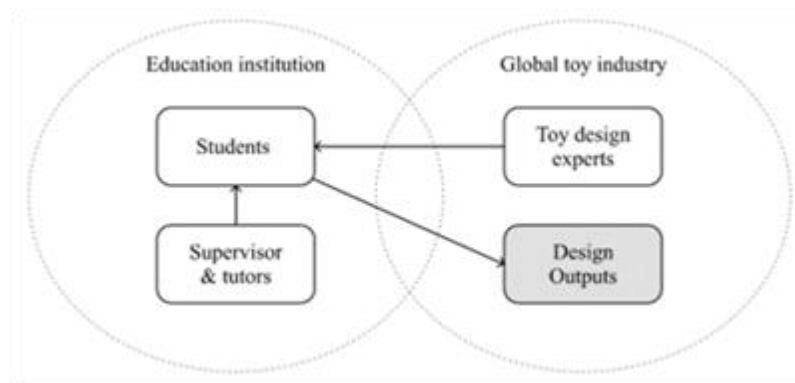


Figure 4: Teaching Objectives: Constructing Intimate Interactions between Academia and Industry.

3.4 Implementation

As illustrated in Figure 5, the implementation phase follows a meticulously planned curriculum. Within this programme, students were guided to draw on their prior knowledge of design research methods and ideation techniques, alongside new practical skills gained from the current WIL course, to invent toy products for the global market. Over the semester, students completed two group projects. The first two-week capstone project served as a short-term introductory exercise designed to cultivate students' inventive thinking in toy design, thereby laying the groundwork for the subsequent major project. The second capstone project, extending over a month, imposed more stringent requirements on the quality of the final output. The students' creations were ultimately subjected to joint evaluation by PolyU Design and the industry partner, with promising designs receiving corporate sponsorship for production and potential market release as actual toy products. To capture sufficient behaviours and feedback from participants, we offered a variety of instructional formats, such as lectures, workshops and co-instructed tutorials in blended settings (see Figures 6 and 7).

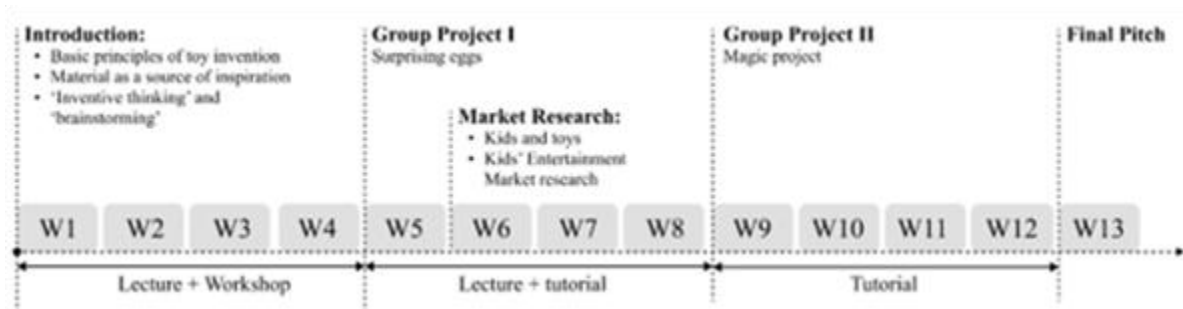


Figure 5: Curriculum Arrangement



(a) Lectures provided by the professional toy inventors from industry partner's headquarter - Distancing



(b) Lectures provided by the experts from industry partner's HK branch - Co-located

Figure 6: Lectures Provided by Global and Local Industry Design Experts



Figure 7: Tutorials Provided by Global and Local Industry Partners

3.5 Evaluation

The evaluation of the B-WIL framework focuses primarily on two dimensions: observing students situated design process, particularly their navigation of socio-material boundaries, and their subjective perceptions of skill and knowledge acquisition and learning outcomes. To capture this longitudinal data, each group submitted group reflection reports after completing each of the two design projects.

These reports followed two distinct pedagogical prompts. First, students were asked to reconstruct their collaborative design trajectory, detailing the workflow from ideation to final prototyping. This section explicitly required students to document critical design episodes, specific obstacles or socio-material frictions encountered, and the strategies employed to resolve them. Second, students conducted a metacognitive review, reflecting on the competencies and professional identities they believed the curriculum enhanced or helped them acquire. Using reflection reports as the primary data corpus aligns with WIL's participatory and experiential nature. By critically revisiting their learning trajectories, students become active participants in their educational journey, transforming assessment from a static measure of outcomes into a dynamic process of agency and self-awareness (Earl, 2013). This qualitative approach allows researchers to identify not only what challenges arose and what knowledge was gained, but also how students negotiated impediments and internalised new skills within the blended learning environment.

To interpret this dataset rigorously, this study employed a dual-track qualitative analysis strategy, combining deductive and inductive approaches to capture both the mechanisms of the B-WIL framework and its outcomes. We collected 28 group reflection reports, 14 from each of the two projects. We implemented a rigorous dual-coder protocol to ensure analytical validity. Two coders, each with over three years of design research experience, independently processed the student reports in Atlas.ti. A randomly selected 15% of the total dataset, specifically the four reports produced by two student groups (two reports per group, one from each project), were coded independently by both coders to establish inter-coder reliability. Reliability was quantitatively assessed using Cohen's Kappa, yielding $\kappa = 0.86$, indicating substantial agreement. The two coders resolved all coding discrepancies identified during this initial phase through consensus discussions. In instances where mutual agreement could not be reached, a senior researcher served as an independent adjudicator to review the raw data and render a final decision. After resolving all disagreements, the two coders collaboratively refined and unified the codebook to ensure a consistent analytical framework. The remaining 85% of the dataset (24 reports) was divided equally. Each coder undertook twelve reports, corresponding to six groups' submissions for both Project 1 and Project 2, and coded them independently against the finalised codebook. Finally, upon completion of this independent coding, the two coders thoroughly cross-checked each other's coded segments to detect any potential drift or oversight. Any newly identified discrepancies were again resolved through consensus negotiation, ensuring the final coded corpus reflects the reconciled consensus achieved through this rigorous, iterative process.

3.5.1 The process analysis: Deductive content analysis

To understand how the B-WIL framework influenced the collaborative learning process, we applied a deductive content analysis. This track focused on the first section of the reflection reports (design activities). Using a predefined coding frame, we traced the causal chains of "critical design episodes", linking specific difficulties to specific actions and support agents, leading to subsequent resolutions (see Table 2).

Table 2: Coding Schemes of Deductive Content Analysis

Codes		Descriptions
Difficulty	Contextual Dissonance	Instances where students situated local knowledge (e.g., regional slang, cultural aesthetics) conflicted with the universal scalability requirements of the Global Expert. This represents a "cultural translatability gap".
	Misinterpretation/ Interpretive Disconnect	Episodes where students failed to cognitively decode the strategic feedback or abstract instructions provided by the global design experts, resulting in confusion regarding the design direction.
	Design Fixation	Moments where the team exhibited "iterative stagnation" (Jansson & Smith, 1991), adhering blindly to an initial concept despite negative feedback or material failure, unable to generate alternative solutions.
	Prototype Failure	A material breakdown where the physical artifact failed to meet functional, safety, or ergonomic standards during testing. This represents a "socio-material rupture" where the digital design could not survive physical reality.
	Group Conflicts	Social friction arising from internal disagreements regarding task distribution, creative direction, or workload management among student team members.
Action	Professional Support	The proactive solicitation of guidance from mentors. This code captures the vertical movement of seeking expert authority to resolve ambiguity.
	Peer discussion	Collaborative dialogue within the student team aimed at resolving social conflicts or brainstorming solutions without external intervention.
	Online research	The independent sourcing of information via digital platforms (web searches, database reviews) to bridge knowledge gaps, often used as a first-line response before seeking mentorship.
	Repeated experiments	An iterative process of trial-and-error where students engaged in rapid physical prototyping cycles to test hypotheses and resolve material failures.
Agent	Global design expert	The virtual international mentor. This agent represents the "market voice," providing high-level strategic constraints and feedback via digital channels.
	Local industry partner	The co-located industry mentor. In this analysis, this agent functions as the "boundary spanner," physically present to translate feedback and validate prototypes.
	University tutor	The academic instructor, primarily associated with pedagogical scaffolding, grading criteria, and general design education support.
	Groupmate	Fellow student team members who served as the primary resource for collaborative problem-solving and peer support.
	Target User	External participants (children/parents) involved in user testing, providing validation or rejection of the toy's playability.
Outcome	Contextual re-framing	The successful adaptation of a local concept to meet global standards. The core identity of the design is preserved but "translated" for a wider audience.
	Epistemic translation	The successful decoding of abstract global feedback into actionable local tasks. This outcome signifies that the "Interpretive Disconnect" was resolved, usually through brokerage.
	Reaching consensus	The resolution of social friction, resulting in a unified team agreement on the design pathway.
	New inspiration	The generation of novel design features or concepts, breaking a state of Design Fixation.
	Directional re-framing	A significant pivot in the design strategy where the initial concept is abandoned in favour of a new direction based on external constraints.

Codes		Descriptions
	Successful prototype	The achievement of a functional, validated physical model that resolves previous material failures and meets safety/ergonomic criteria.
Design Phase	Design Phase 1	Design Ideation: The early conceptual phase focused on brainstorming, sketching, narrative development, and defining the "toy concept" before materialization.
	Design Phase 2	Prototyping and Testing: The phase involving the translation of 2D sketches into 3D physical models, material experimentation, and functional testing.
	Design Phase 3	Refinement and Final Product: The concluding phase focused on aesthetic polishing, safety compliance checks, packaging, and the final presentation of the artefact.

3.5.2 The outcome analysis: Thematic analysis

Complementing the process tracing, an inductive thematic analysis was applied to the second section of the reports. This open-coding approach allowed themes related to students perceived professional growth to emerge, identifying key competencies not predetermined by the theoretical framework. Three quotation typologies were systematically identified: (1) discrete quotes containing explicit keywords, (2) embedded quotes revealing perspectival shifts, and (3) longer descriptive quotes illustrating metacognitive processes. Keywords were extracted following the 6Rs principle and collaboratively discussed to draft a preliminary coding scheme. Following two coding cycles, keywords were systematically mapped to codes through iterative refinement, adding new codes and revising existing ones while revisiting raw data. After analysing 24 reports (12 student groups), we observed that no new codes or themes emerged from the data, indicating that thematic saturation had been achieved. To confirm stability, we analysed the remaining four reports (the final two groups), and this additional analysis yielded no novel thematic content, affirming that saturation held across the full corpus of 28 reports. Coders then reconciled discrepancies through cross-checking and consensus discussions, excluding irreconcilable segments (<2% of total data). Ultimately, we identified three core themes in students' perceived growth, namely sociomaterial fluency, contextual agility, and cross-boundary communication (see Table 3).

Table 3: Three Core Themes Determined through Thematic Analysis

Theme	Descriptions	Sub-themes	Keywords
Socio-material Fluency	The student's ability to navigate the epistemic gap between abstract digital interactions and concrete physical realities. It is the communicative ability to use material evidence, such as safety checks, and functional prototypes, to validate design concepts against the strategic demands of a remote expert who cannot physically touch the object.	Iterative Experimentation	Prototyping; Hands-on experience; The spirit of experiment; Various materials
		Material Verification	Validation; Material failure; Checking safety; Ergonomic testing; Considering cost of design; Feasibility; Balancing creativity with practical constraints
Contextual Agility	It refers to the students' capacity to mentally shift between situated local constraints and global imperatives.	Cultural Awareness	Diverse perspective; Current/future market trends; Cultural differences; Current/future market trends
		Professional/consumer Alignment	Profession critiques, Industry expectation, Contextual re-framing;

Theme	Descriptions	Sub-themes	Keywords
			Child-centred ways; Cognitive development theory; Sustainable materials
Cross-boundary Communication	It describes the students' capacity to articulate complex, tacit design intentions across spatial, cultural, and professional boundaries	Collaborative Resilience	Teamwork, Problem-solving, Professional partnership, Networking, Group conflicts
		Distancing Communication	Visual communication; Technological adaptation; Reasonable storytelling

To ensure the rigour of our qualitative interpretations, we systematically applied Lincoln and Guba's (1985) trustworthiness criteria across both analytical tracks. Credibility was ensured through peer debriefing, dual-coder cross-examination, iterative consensus-building, and triangulation of data sources across the two project cycles and multiple student groups. Transferability was ensured by providing thick descriptions of the B-WIL pedagogical context and the specific localised industry dynamics. Dependability and confirmability were ensured by maintaining a comprehensive audit trail documenting all analytical decisions, coding iterations, and team deliberations throughout both the deductive and inductive processes.

4. Findings

4.1 Finding 1: The Shifts from Ideation to Materialisation

The subsequent alluvial diagrams reveal distinct structural differences in how students navigated socio-material barriers across the design phases. Figure 8 illustrates the resolution pathways during Phase 1 (Design Ideation), where the dominant flows originate from abstract cognitive obstacles associated with Design fixation and Contextual dissonance. As indicated by the bandwidth of the connection flows, students primarily resolved Design Fixation by seeking strategic support from global design experts and engaging in collaborative online research with peers. Participants reflected that these interactions were instrumental in breaking iterative stagnation and providing new inspiration that directed them towards novel conceptual avenues. However, regarding Contextual dissonance - instances where students' local knowledge (e.g., regional slang or specific cultural aesthetics) conflicted with the universal scalability requirements of the global experts - the diagram shows a strong convergence towards the Local industry partner. Acting as a central epistemic agent, the Local partner effectively channelled these conflicts into the outcome of Contextual re-framing. This highlights the partner's role as a cultural broker who bridged the "translatability gap," guiding students to retain the essence of their local identity while repositioning the design entity to align with broader global contexts.

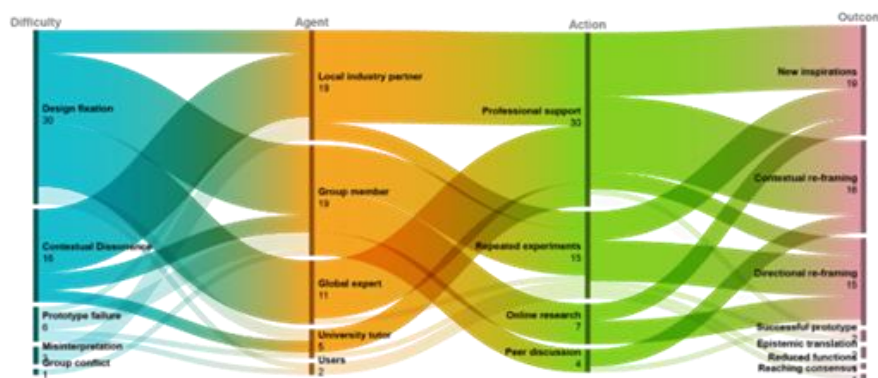


Figure 8: Difficulty-Agent-Action-Outcome pathway in design phase 1

In contrast, Figure 9 delineates the pathways during Phase 2 (Prototyping and Testing), where the locus of difficulty shifts significantly towards material and interpretative challenges. The most prominent difficulty node

is Prototype failure, marking the transition from abstract ideation to physical realisation. Here, the local industry partner remains the central node but shifts function from cultural translation to technical scaffolding, assisting students through professional support and repeated experiments to achieve successful prototypes. Unlike in Phase 1, global experts were less dominant in addressing design fixation during this stage; instead, students relied on the generative nature of the prototyping process itself, supported by local tutors and the feedback of target users, whose input accelerated decision-making and screened out ineffective solutions. Notably, a critical pathway emerged regarding Misinterpretation, defined as students' failure to cognitively decode abstract strategic feedback from global design instructors. A recurring example involved students misinterpreting expert critiques regarding the "educational impacts" of a toy as a directive to abandon educational features entirely. In these instances, the local industry partner intervened to re-interpret the feedback, clarifying that the experts were critiquing the prioritisation of education over fun, not its inclusion. This intervention corrected the design direction without invalidating the global expert's input. Ultimately, these shifted patterns indicate a fundamental transition in the mechanism of repair: from cognitive decoding and cultural alignment in the ideation phase to socio-material coordination and interpretative calibration in the fabrication phase.

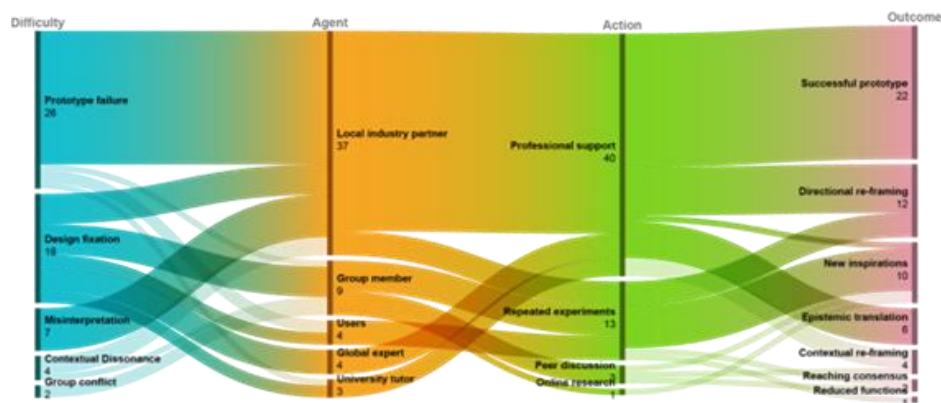


Figure 9: Difficulty-Agent-Action-Outcome Pathway in Design Phase 2

4.2 Finding 2: Behavioural Shifts Between Projects

Although the aggregate frequency of reported design challenges was evenly distributed across phases in both projects, a comparative analysis of the resolution trajectories - illustrated in Figures 10 (Project 1) and 11 (Project 2) - reveals a distinct longitudinal evolution in problem-solving maturity. In the design ideation period of Project 1, students were primarily occupied with abstract cognitive hurdles, specifically design fixation and contextual dissonance. In contrast, the ideation phase of Project 2 saw the emergence of difficulties related to prototype failure, a category entirely absent from the first phase of Project 1. This structural anomaly suggests a "shift-left" in the students' workflow: rather than treating prototyping as a late-stage validation step, students in Project 2 entered the prototyping phase significantly earlier. The data indicate that they began utilising material engagement not only for testing but also as a generative heuristic to generate inspiration and resolve conceptual stagnation.

This earlier engagement with materiality significantly improved design workflow efficiency. In Project 1, Design fixation proved highly persistent, remaining a dominant obstacle well into design phase 2 and accounting for nearly half of the reported difficulties. Furthermore, technical challenges in Project 1 were often delayed, with a high frequency of prototyping difficulties remaining unresolved until design phase 3 (refinement and finalisation). Conversely, Project 2 followed a more efficient resolution curve. By Phase 2 of the second project, reports of Design fixation had become negligible; the students' focus had shifted almost entirely to technical refinement. Crucially, the late-stage technical bottlenecks observed in Project 1 were largely absent in Project 2, as the majority of material frictions were successfully identified and resolved during the first two design phases.

Underlying these temporal shifts is a fundamental transformation in students' behavioural patterns and help-seeking strategies. The analysis clearly delineates a shift in the "mechanism of repair" regarding Design fixation. In Project 1, students showed high epistemic dependence, relying heavily on professional support. By Project 2, this reliance on external authority had diminished. When facing similar conceptual blocks, students increasingly resorted to peer discussion combined with repeated experiments. This behavioural pivot correlates directly with the early emergence of prototype failure noted in the first observation; students were no longer waiting for

expert permission to proceed but were instead using autonomous material experimentation as a primary means to overcome fixation. Ultimately, these behavioural shifts highlight a change in the nature of the student-broker interaction, moving from a model of dependency on external direction towards a more collaborative, validation-seeking engagement model characterised by increased internal agency.

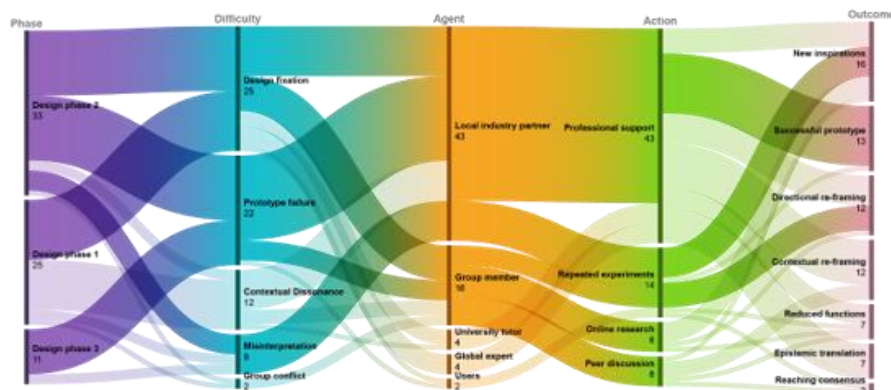


Figure 10: The problem-solving pathways in design project 1

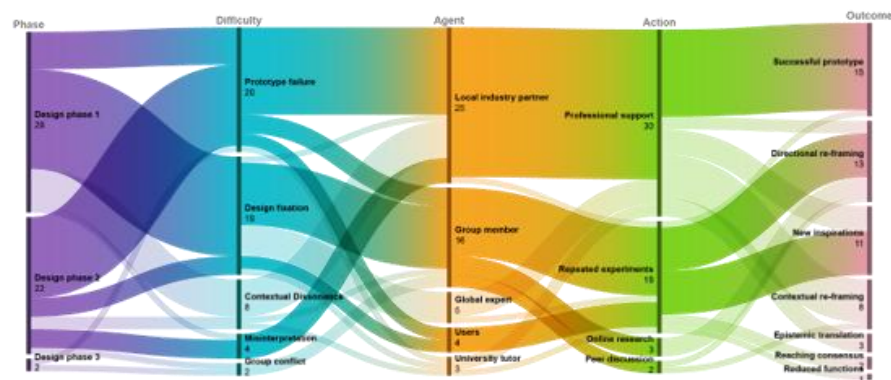


Figure 11: The Problem-solving pathways in design project 2

4.3 Finding 3: The Development of Students' Competences

As illustrated in Table 4, frequency analysis was conducted using the query tool in Atlas.ti, measured the distribution of each sub-theme, representing different potential capabilities that may be improved through this B-WIL curriculum, based on observations of students' design activities and their self-reported strengthening of competence.

Table 4: Frequency Analysis of Key Thematic Categories

Theme	Sub-themes	Frequency	Percentage (%)
Sociomaterial Fluency (38.4%)	Repeated Experiments	83	16.6
	Material Verification	109	21.8
Contextual Agility (38.2%)	Cultural Awareness	78	15.6
	Professional/consumer Alignment	113	22.6
Cross-boundary Communication (23.4%)	Collaborative Resilience	62	12.4
	Distancing Communication	55	11.0

As illustrated in Table 5, Project 1 reflections were characterised by a “future-oriented” narrative structure, in which students identified specific sociomaterial deficits (e.g., ‘Our video didn’t show...’) and proposed hypothetical strategies. In contrast, Project 2 reflections showed a “retrospective-competence” structure, in which students reported successfully applying specific strategies (e.g., ‘We used the visual storyboard...’). This

epistemic transition supports the observations in finding 2, namely the reduced dependence on external authority when students conducted Project 2. It also indicates that the competencies reported in Project 2 were directly rooted in the sociomaterial frictions encountered in the initial project.

Table 5: Instances of Different Narrative Structures in Project 1 and Project 2

Perceived Ability Enhancement	Project 1: Future-oriented (Focus on deficit & planning)	Project 2: Retrospective-competence (Focus on strategy application)
Sociomaterial Fluency	<i>"We should conduct user testing and safety testing as early as possible next time to identify potential risks, such as kids might accidentally eat parts of toy that are designed to resemble food."</i>	<i>"We conducted a stress test using the workshop to produce data, to convince the design experts that our safety features were valid."</i>
Contextual Agility	<i>"We initially realised that creating toys based on a specific culture or theme with a limited audience might result in fewer children understanding and purchasing the toy"</i>	<i>"Combining Japanese washi art with Western mechanical design elements may result in a unique toy creation."</i>
Cross-boundary Communication	<i>"Our video didn't show that the toy could be taken out to play around, which misled design experts into thinking that the toy couldn't be detached from the unboxing."</i>	<i>"Using the visual storyboard allowed us to articulate the play pattern clearly. The visual narrative bridged the gap, and the expert understood the concept immediately without physically interaction."</i>

5. Discussion

5.1 The Local Industry Broker as An Epistemic Scaffold

Based on the resolution pathways mapped in Finding 1 (see Figures 8 & 9), the local industry partner emerges as the primary epistemic agent responsible for resolving issues of two-sided "contextual dissonance" and "misinterpretation" between remote experts and students. We conceptualised this role as that of a "boundary broker", an intermediary who connects otherwise unconnected actors by facilitating the flow of information (Wenger, 1998). This brokerage involves more than mere supervision; it also requires the active translation of socio-cultural confusion. This was evident when cultural gaps hindered the global expert's comprehension of local symbolism. For instance, one student group noted, "Roy did not understand that there would be a ghost hiding inside the well, since a well is more often used for coin tosses to make wishes in western culture." In this instance, the local partner served as a "translation agent" (Eversole, 2018), bridging the gap by utilising auxiliary materials, such as images associating wells with a "terrifying atmosphere", to align the expert's understanding. This intervention also had a tacit pedagogical effect that aligns with the behavioural improvement observed in Project 2, in which students proactively contextualised their concepts prior to presenting, effectively internalising the broker's communication strategy.

Beyond cultural translation, the local broker played a critical role in reframing feedback when students misinterpreted global critiques as outright rejection. Novice designers often struggled to decode abstract directives, reporting confusion regarding "what the 'fun' or 'playfulness' highlighted by design experts actually means." In these cases, the local partner transformed an abstract critique into an empirically verifiable metric by guiding students to evaluate "funness" through workshops with target users and observing "wow" moments. This aligns with research on "interpretive brokerage," where intermediaries help peripheral participants decode the practice of experts, preventing disengagement caused by misunderstanding (Kubiak et al., 2014).

Moreover, during the prototyping phase, the broker's role expanded from cognitive translation to sociomaterial validation. As the global expert was epistemically constrained by the screen interface (unable to assess physical properties such as weight, texture, or safety), the local partner served as a "proxy validator." By conducting on-site stress tests and ergonomic assessments, they provided the material certainty required for students to proceed. This validation effectively de-risked the innovation process, enabling students to attempt complex technical experiments they might otherwise avoid. This is vividly illustrated by one team's account: "With the support of design technicians, we experimented with boiling baking powder to create sodium hydroxide... We eventually sourced high-concentration chemicals and carefully diluted them." Without the physical presence of a broker to oversee safety and efficacy, such material experimentation would be impossible in a purely virtual mentorship model.

Finally, the consistent presence of a supportive local broker fostered a "psychologically safe" studio environment, which directly influenced the behavioural shifts documented in Finding 2. The data show an earlier

and more frequent incidence of “repeated experimentation” in the second project cycle (see Figures 10 & 11). Students reported feeling empowered to use the local partner not merely as a supervisor but as a confidential sounding board for testing novice ideas before exposing them to the global audience. This indicates that the broker functions as an affective scaffold, reducing the interpersonal risk associated with failure and encouraging the iterative risk-taking essential for design progress.

5.2 The Emergence of “Trans-Boundary” Design Competencies

The thematic analysis indicates that the B-WIL curriculum supported the emergence of three distinct “Trans-Boundary” competencies: Sociomaterial Fluency, Contextual Agility, and Cross-boundary Communication. However, these advanced capabilities were not an inevitable outcome of the course; they emerged as a process of metacognitive transformation triggered by productive friction at the boundaries of different practice communities. In the first project cycle, the prevalence of deficit-identification codes (Finding 1) seemed to function as an epistemic awakening. By encountering specific barriers, such as the inability to validate material selection remotely or the failure to decode global strategic feedback, students were prompted to confront the weaknesses of their existing studio habits. This initial dissonance visualised the boundaries that primed students for the explicit, strategic learning observed in subsequent phases. Notably, this finding reinforces the notion that boundaries carry significant learning potential, as they can foster an active shift in perspective and help transform “friction” into a learning resource (Akkerman and Bakker, 2011).

Sociomaterial fluency represents a notable shift in the prototype’s ontological role within students’ accounts. In traditional design studios, prototypes often serve merely as “drafts” for the designer’s own reflection. The B-WIL context, however, encouraged students to instrumentalise prototypes as tangible evidence for negotiating reality with remote experts. This competency was observed to bridge the digital-physical gap, mitigating the risk that material constraints, such as safety, ergonomics, and playfulness, would be lost in virtualisation. For instance, rather than attempting a complete, polished model, students reported learning to use a “fragmented prototyping” strategy. They created distinct rudimentary artefacts to isolate specific variables, such as mechanics, aesthetics, or play patterns. In doing so, they transformed the low-fidelity prototype from a sketch for self-exploration into a social tool for virtual negotiation.

Additionally, Contextual Agility helped reframe students’ cultural identity from a barrier to a strategic asset. Students noted an interesting disparity between the global and Asian markets: “It is interesting to focus on excitement or applying elements to a new design, while culture in Hong Kong always asks for value and efficiency for doing anything,” and “we often focus on specific goals and create detailed concepts and models. However, toys are just for fun, and they don’t have to be as complicated as we think.” Rather than diluting their local aesthetics to fit a generic global standard, students’ reflections suggested they developed a dual-scale vision, acquiring the agility to detach specific local signifiers while retaining the underlying cultural ethos. Students reflected on learning to appreciate the nuances of designing toys that appeal to diverse cultural backgrounds: “We linked many elements together or linked two totally irrelevant elements together, but it is not easy to understand. A balance between humour and expectancy is important, such as preventing too complicated elements and idioms not existing in other languages.” This finding suggests that hybrid mentorship can cultivate designers who are “locally anchored, but globally compatible,” capable of aligning specific cultural values with universal market trends.

Furthermore, student reflections show enhanced cross-boundary communication. Recognising the limitations of verbalisation in cross-cultural communication, students learned to adopt visual narratives as effective boundary objects. This capability enabled them to articulate tacit, studio-based knowledge, such as the abstract sensation of “playfulness”, in an explicit format legible to remote audiences. For example, to demonstrate an emotional “play pattern” that could not be felt through a webcam, students created narrative-driven video storyboards that contextualised the toy within a user scenario. This visual artefact ensured that the design intent survived digital transmission, allowing the expert to evaluate the “fun factor” without physical interaction.

Crucially, the B-WIL framework enabled students to internalise the brokerage functions initially performed by the local professional partner. As the locus of control shifted from external dependency to internal agency, students began to apply the strategies they had observed or learned. This transition, from “passive recipient” in Project 1 to “active agent” in Project 2, scaffolded the development of a unique hybrid professional identity. Students not only acquire technical skills but also develop the ability to navigate the epistemic boundaries between local constraints and global standards.

6. Limitation and Future Work

This study acknowledges several constraints that affect generalisability and methodological robustness. First, although student reflection reports provided rich qualitative insights, the limited cohort size and disciplinary concentration constrain statistical generalisability. This demographic homogeneity, together with a primary reliance on self-reported data, introduces potential perceptual biases. Future work should integrate real-time behavioural metrics (e.g., design iteration logs) and pre- and post-competency assessments to empirically validate claims about skill development across larger, interdisciplinary cohorts. Additionally, because the course instructor also served as the principal investigator, inherent conflicts of interest may have influenced data interpretation. This dual role risked assessment bias, such as unconscious bias in grading student work linked to research outcomes, though we implemented safeguards such as anonymised student reflections and dual-coder analysis. Future studies should separate teaching and research roles or include external evaluators.

Second, the model's success hinges on Hong Kong's robust university-industry ecosystem and the presence of numerous multinational branches, enabling local partners to mediate global expertise. Therefore, replicability in regions lacking dual-scale industry networks or institutional partnerships may require further modifications. Subsequent research should explore region-agnostic implementation guidelines to account for resource disparities and to incorporate structured industry assessments of the model's operational feasibility in future iterations.

7. Conclusion

In the contemporary era of global media, the educational landscape is rapidly shifting towards a digitally dominant paradigm. While this transformation offers exciting prospects, educators must remain vigilant as the classroom increasingly detaches from physical reality and drifts toward a disembodied, virtual existence. This digital transition poses a fundamental challenge to the core tenet of Work-Integrated Learning (WIL): situated learning. Existing literature frequently notes that such environmental isolation exacerbates estrangement between students and industry instructors, which can compromise the effectiveness of knowledge acquisition and transfer.

To address this challenge, this study proposes a novel Blended WIL (B-WIL) framework that strategically integrates local professional partners as "boundary brokers." These brokers interconnect the other three critical stakeholders within the WIL ecosystem: global experts, student teams, and institutional tutors. By evaluating this dual-scale industry participation, this research offers qualitative insights into how situated learning can be sustained in a digital era, offering vital theoretical, pedagogical, and practical contributions to the field.

Theoretically, this study advances the discourse on boundary crossing in digital education by operationalising the concept of a "blended ecology." This offers a new conceptual lens for understanding how the contextual gap between disembodied global networks and situated local practice can be navigated. The research positions the local partner not merely as an administrative assistant but as a critical boundary broker who executes the dialogical mechanisms of coordination and translation.

Pedagogically, the study provides rich qualitative accounts suggesting that the B-WIL model fundamentally alters students' learning trajectories. Based on the self-reported data, introducing the localised brokering shifts students' problem-solving behaviour from passive recipients to active agents. This pedagogical intervention was found to facilitate the acquisition of unique trans-boundary design abilities, equipping students to confidently navigate the complex intersection of global strategy and local execution.

Practically, this research offers a concrete, actionable template that extends beyond the immediate context of design education, suggesting potential for cross-disciplinary transfer and adaptation. By creating a synergistic ecosystem in which virtual global expertise integrates with co-located industry mentorship, the framework helps address critical gaps in both conventional and purely remote WIL formats. This model is particularly adaptable to disciplines that require a synthesis of conceptual innovation and hands-on practice, such as STEM, architecture, and business. The local boundary broker, functioning as the system's connective tissue, can adapt to various cross-border partnerships. For example, in software engineering, multinational tech firms might provide remote project ideation, while regional startups facilitate agile, on-site development. Similarly, business programmes could pair global consultancies with regional SMEs. Ultimately, the B-WIL framework provides a highly scalable and adaptable template for institutions seeking to maximise international industry connectivity while maintaining the deep, localised support structures necessary for profound situated learning.

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