Expertise at the intersection: How teams develop cross-domain expertise in transdisciplinary capstone projects

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As complex challenges increasingly span multiple fields, integrated learning approaches are essential to foster innovation. This paper examines how students develop expertise through cross-domain collaboration across design, technology, and business within the Garage Experience (GX), a senior capstone at the University of Southern California's Iovine and Young Academy (IYA), structured through a Challenge-Based Reflective Learning (CBRL) framework. Using a mixed-method case study of two contrasting teams, we analyze how students identify, negotiate, and respond to expertise gaps over time. Findings show that in this capstone setting, expertise is developed relationally, with teams following two pathways: coordinated, role-based expertise with incremental expansion of identified knowledge areas, and fluid redistribution of expertise with broader integration across areas. Exposure to technology, design, and entrepreneurship through Challenge-Based Reflective Framework supports expertise development by enabling students to recognize and respond to knowledge gaps. These findings highlight the importance of designing capstone environments that support collaboration across evolving areas of knowledge.

Keywords: Challenge-Based Reflective Learning; expertise; collaboration; future of work

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Introduction: Expertise

As the future of work shifts toward rapidly changing, ill-defined challenges, transdisciplinary approaches are becoming essential for addressing complex problems. This shift requires moving beyond singular disciplinary mastery toward "expertise at the intersection"—a professional identity defined by the ability to navigate and negotiate fluid boundaries through problem-solving and iterative learning across integrated domains.

This study examines student collaboration and expertise development across technology, design, and entrepreneurship within the first semester of a senior capstone at the Iovine and Young Academy (IYA) at the University of Southern California. Using IYA's Challenge-Based Reflective Learning (CBRL) model, we show how students develop and negotiate cross-domain expertise through iterative cycles as they prepare for ventures, products, social initiatives. Our findings show how teams adopt different collaboration modes while identifying and acquiring knowledge across technology, design, and business to address aimed challenges. We suggest that CBRL supports an evolving notion of expertise, enabling students to identify gaps and strategically integrate knowledge across domains.

Prior research has challenged the view of expertise as a fixed, individual attribute, instead conceptualizing it as socially recognized, relational and enacted in practice[1,2]. Expertise depends not only on possessing knowledge but on how it is recognized in relation to others[3]. Cross-disciplinary collaboration research identifies *boundaries*—differences in knowledge, practices, and perspectives[4–6]. These boundaries function as both barriers and opportunities for learning through identification, coordination, and reflection[7,8]. Boundary-spanning research shows that collaboration involves transforming and recombining expertise through negotiation [9]. Expertise is often unevenly distributed and must be actively negotiated in practice. This study examines how students recognize expertise and gaps across multiple domains in a transdisciplinary capstone and respond to the differences to achieve project goals.

Context: The CBRL Framework at IYA

The CBRL framework is a novel transdisciplinary model designed to prepare students for the complexities of the rapidly changing world[10]. Rather than starting with a single disciplinary base such as business or psychology, CBRL nurtures students to define the contexts of real-world challenges by utilizing knowledge at the intersection of multiple domains[11]. At IYA, these domains span *technology*, *design*, and *business*. IYA undergraduate students pursue a Bachelor of Science (B.S.) in Arts, Technology, and the Business of Innovation while engaging in courses and projects with topics co-designed by industry partners and local communities. Examples include designing AI tools for creative workflows, wearable assistive technologies for health monitoring, and campus-based delivery systems.

Courses and projects incorporate varying degrees of the four learning phases of CBRL (Figure 1): *Discern* (define the challenge space), *Prompt* (identify perspectives and domain knowledge), *Prototype* (develop and test solutions), and *Iterate/Pivot* (refine or redirect through feedback). Students learn to frame contexts, identify and apply knowledge across domains through hands-on, reflective practice.[11]

In practice, these phases are embedded into course design through milestones, exercises, and feedback that guide students from problem framing to implementation. This study was conducted within the Garage Experience (GX) course, a yearlong capstone where senior teams lead challenge projects. Students completed the CBRL cycle three times, enabling iterative identification of gaps through activities, critiques, and assignments designed by the instructors (Figure 1).

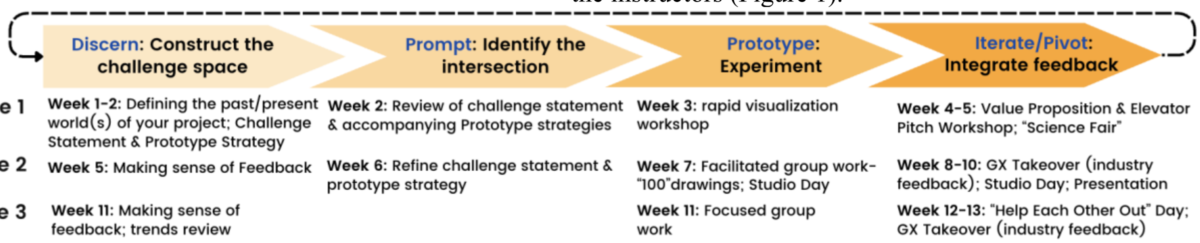

Figure 1. Iterative CBRL cycles and weekly implementation in the GX capstone course

The CBRL requirement for GX is explicitly action-oriented: moving beyond client-oriented deliverables, students launch a startup, test a minimum viable product (MVP) in a target market, or execute a social initiative. The emphasis on real-world outcome nurtures reflective practice through iterative engagement[12]. All GX topics are pre-approved by a faculty committee in students' third year to ensure topic diversity and project feasibility. As students progress together through core CBRL courses, GX teams form around shared interests.

Methods: Participants, Data Collection, and Analysis

We studied the first semester (15 weeks) of GX through a field-based case study methodology, drawing on multiple data sources to examine student collaboration and expertise development.[13] Three research team members collected data from classroom observations (fieldnotes and videos)[14], pre- and post- semester surveys, semi-structured interviews, and artifacts from workshop activities (Week 3 and 7). All 34 IYA students in the course participated. This paper focuses on two teams (Team 1, 4 members; Team 2, 5 members) from 11 teams, analyzing interviews, pre- and post- survey responses on expertise in technology, design, and business, and workshop artifacts capturing teams' identification of gaps and strategies. Teams were selected based on project type (physical vs digital) and sufficient interview completion (4/4 for Team 1; 3/5 for Team 2) with interviews being the primary data source.

During Week 3 and 7, students used a collaborative platform, Miro, to respond to prompts about gaps and strategies for gaining knowledge and skills across technology, design, business, and other domains. The workshop activities were co-designed with the instructor.

Two researchers analyzed post-semester interviews using inductive thematic analysis informed by the Gioia methodology[15], progressing from in vivo language to higher-order conceptual themes. Open coding generated 77 first-order codes for Team 1 and 52 codes for Team 2. Codes on expertise, collaboration, and skills emerged, followed by iterative refinement into higher-order themes through researcher discussion. Workshop artifacts were analyzed using the same coding scheme to identify how teams represented expertise gaps and strategies, while fieldnotes contextualized team interactions and triangulated patterns from interviews and workshop artifacts. Survey data included four measures of perceived expertise on: 1) project topic, 2) technology, 3) business or entrepreneurship, and 4) design. Overall, the analysis examined how teams identified expertise, articulated gaps, and applied strategies to address them.

Findings

The findings show that teams differed in how they identified, negotiated, and developed expertise over time. Both Team 1 (*physical product, smart thermometer*) and Team 2 (*digital service, AI-driven fan sentiment analysis*) were self-formed based on prior collaboration and relationship, allowing members to engage with awareness of each other's expertise. Yet, Team 1 brought engineering backgrounds and entrepreneurial skillsets, while Team 2's expertise centered on human-centered design and user experience (UI/UX). Team 1 viewed their *cross-functional* expertise as a key strength in accelerating their product development cycle. Three members contributed technical expertise in 3D modeling, computer-aided design (CAD), and product development, while another brought entrepreneurial expertise. In contrast, Team 2's design strengths established a shared, design-led orientation.

These differences shaped how expertise gaps emerged. By Week 3, Team 1 recognized gaps in design, particularly digital branding for crowdfunding strategies while focusing on advancing MVP. In contrast, Team 2 quickly surfaced gaps in technical implementation, including coding, data processing, and computer vision.

Based on these gaps, the two teams also followed distinct strategies. By Week 7, Team 1 maintained stable, role-based expertise while exploring resources in digital branding and fundraising. They learned by interacting with peers outside of their team. Team 2, on the other hand, redistributed expertise across members to meet technical needs. One member with data science interests took on a technical role. Other members explored alternative tools to prototype and analyze initial data (e.g., no-code and AI tools) by drawing on faculty, industry experts, and informal networks. The team also pivoted toward refining business positioning and market validation rather than full technical development.

Throughout the course, both teams recognized strengths and gaps across design, technology, and business. Through the CBRL cycle, they developed awareness of their boundaries while learning to acquire new skills or negotiate expertise. Table 1 synthesizes these patterns, suggesting that cross-domain collaboration followed different pathways—either coordinating within established expertise or actively reshaping it through learning, redistribution, and pivots.

	Team 1: Physical product	**Team 2: Digital service**
Team composition	4 members (4 male)	5 members (3 male, 2 female)
Challenge space	Accelerating product design cycle through a smart meat thermometer	AI-driven tools to analyze fan sentiment in live events
Action goal	Physical product innovation and venture	Digital service development
Initial expertise	**Tech** (n=3-4; prototyping, hardware, CAD) **Business** (n=1-2; agile process; marketing)	**Design** (n= 4-5; UI/UX, experiential design)
Key knowledge gap	**Design** (digital branding) **Business** (digital marketing)	**Technology** (data processing, computer vision)
Initial collaboration	**Cross-functional coordination** (clear division of functional roles)	**Shared functional orientation**
Collaboration strategy	Leveraged existing technical strengths to advance MVP; addressed tech/design gaps through self-directed resources and prior product launch experiences	Assigned members to explore technical development; others acquired technical skills (e.g., no-code, AI) through collaboration, coursework, and self-learning
Outcome	Stronger coordination; role-based expertise development; conservative pivots into other domains	Fluid expertise sharing and shared learning; greater expansion into other domains; higher effort to build role-based coordination

Table 1. Selected teams' composition, expertise shared, knowledge gaps, and strategies

Survey responses reflected patterns of the qualitative findings. As shown in Figure 2, Team 1 (n=3 matched responses) began the semester with high confidence in topic and technical expertise. While maintaining high confidence, they showed small but positive gains in business (3.67 to 4) and design (4.67 to 5). Team 2, with a single student who responded to both surveys, reported improvement in topic (3 to 4), technical (1 to 2), and business expertise (3 to 4), while design confidence remained stable. Formal statistical testing is not appropriate given the small sample size; descriptive trends show improvement in areas where students identified as gaps across the three domains.

In sum, findings indicate two modes of expertise development and collaboration. Team 1, with clearer role distribution, emphasized cross-functional coordination to maintain engineering expertise while incrementally exploring new knowledge in design and digital marketing. Survey results also showed modest gains in business and design. Team 2, with overlapping design expertise, adopted a fluid approach by redistributing roles and building technical capacity while making broader project pivots into adjacent business domains.

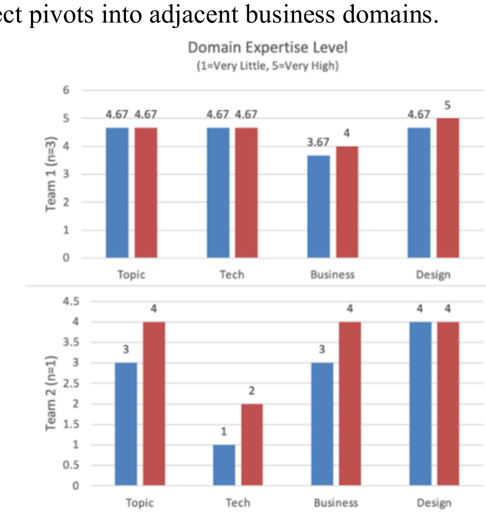

Figure 2. Pre- and post-semester domain expertise rating for Team 1 and 2 across four domains (Overall topic, Tech, Business, and Design) measured on a 1-5 scale.

Discussion and Future Work

Across both teams, developing expertise in GX involved recognizing and mobilizing expertise across domains. Gaps emerged early yet differed based on team composition and project goals. In this capstone setting, where students define challenges across technology, design, and entrepreneurship, they integrated cross-domain expertise in response to identified gaps. While expressing confidence in existing expertise, additional needs emerged as teams followed distinct pathways shaped by project demands.

Two mechanisms appear to support this process. First, IYA's curriculum exposes students to design, technology, and business from early stages, enabling them to recognize and draw on the intersections. Students learn to discern perspectives across domains, positioning their skillsets accordingly. For example, courses such as back-end development introduce coding alongside applications in user behavior and business analytics, reinforcing integrated learning. Second, GX course provides structured opportunities—through prototyping, feedback, and collaboration—for teams to externalize knowledge differences[5] and align work through CBRL[10]. Students leverage each other's expertise as an ongoing negotiation, supporting a socially constructed view of expertise where knowledge is enacted collectively[1,2].

These findings point to opportunities to examine a fluid notion of expertise in which actors enact multiple boundary-crossing knowledge identities while responding to evolving transdisciplinary problems[10]. Such work may reveal understanding of expertise development in contemporary work contexts where domains and roles continue to shift.

This study is limited by its focus on two teams and project types (physical vs. digital), which may shape collaboration strategies and expertise distribution. Further analysis is needed to better understand cross-domain interactions and how students navigate evolving expertise boundaries over time. Future work will extend these findings to better explain how expertise develops in transdisciplinary learning environments relevant to today's rapidly evolving sociotechnical work landscape.

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