INTEGRATING DESIGN THINKING TO FOSTER PATENTABLE INNOVATION IN DESIGN EDUCATION

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ABSTRACT

Design education is increasingly challenged to align creative outputs with real-world innovation and intellectual property (IP) generation. This study presents a pedagogical framework that integrates the Design Thinking methodology into the design process to support the development of patentable products within an undergraduate design curriculum and addressing the growing demand for applied innovation within higher education. The model was applied over different academic programmes, i.e. Industrial design and Interior Design, with a senior-level practice-based courses, structured around the five stages of Design Thinking: Empathise, Define, Ideate, Prototype, and Test. Students were guided not only through user-centred research and iterative prototyping but also through a tailored framework for IP screening, novelty assessment, and patent drafting. The approach aligns with national innovation strategies and reflects a global shift in design education moving beyond traditional instruction toward producing solutions that are not only creative but also protectable and commercially viable. Assessment rubrics were redefined to include indicators for technical originality, feasibility, and IP potential.
The outcomes included several high-quality design concepts, of which the majority were filed as patent applications. This integration demonstrated that undergraduate academic environments could serve as innovation incubators, transforming design outcomes into protectable and potentially commercialise products. It also fostered an entrepreneurial mindset among students, encouraging them to think beyond academic deliverables toward transformative innovation.

Keywords: Intellectual property (IP), design thinking (DT), design pedagogy, industrial design education, interior design education, design-studio practice, design patents, design innovation

1 INTRODUCTION

Design Education has been evolving through major industrial and technological transformations. During the industrial revolution, Design education marked a pivotal shift to prioritise mass production, mechanisation and systematic manufacturing processes [1]. This transition promoted design educational institutes to meet industrial demands by aligning their curricula with such needs while emphasising interdisciplinary knowledge, problem-solving skills and teamwork, in which to support industrial growth [2]. In light of this, Design Thinking (DT) has become one of the lead players in the pedagogical transformation of the approach, which reflects significantly upon design education [3]. Unlike the traditional approaches for design education, Design Thinking focuses on real-world problems, active and collaborative learning where the user is the focus of the process, which promotes innovative solutions and challenge teacher-centred models [4].
This research presents the transformation of design concepts from practice-based courses into patentable innovations within design programmes. This was achieved through integrating a structured innovation-to-patent framework into design curricula that guides the process to produce innovative patentable work. Following this framework, both students and faculty members are encouraged to develop design solutions that are sustainable and high in commercial value, which in turn expands beyond the academic deliverables.

2 DESIGN THINKING AND PATENTABLE INNOVATION IN DESIGN EDUCATION

Design thinking frameworks have been implemented to design education, offering structured approaches that foster innovation, problem-solving, and user-centred innovation. These frameworks generally highlight iterative processes, user-focused empathy, and collaborative ideation, closely aligning with educational objectives that foster critical thinking and practical skills. [5]. Stanford's approach, for instance, is one of the widely used frameworks in design education, it outlines five stages: Empathise, Define, Ideate, Prototype, and Test. This model promotes a human-centred approach by prioritising user needs and supports iterative learning through prototyping and feedback, fostering resilience and adaptability [6].

Another widely adopted framework is the Double Diamond model, developed by the UK Design Council, which structures the process into four phases: Discover, Define, Develop, and Deliver. It highlights divergent and convergent thinking cycles, enabling students to explore broad problem spaces before refining feasible solutions [7]. Its clarity and simplicity make it effective for teaching complex design processes in an accessible manner. In addition, hybrid design thinking frameworks have emerged to address discipline-specific or learning outcomes needs. These include approaches that integrate storytelling and systems thinking to support holistic problem-solving, as well as participatory models that prioritise co-creation and stakeholder involvement to foster empathy and collaboration.

The integration of these frameworks in design education reflects a shift from traditional, linear design methods to a more flexible, user-centred approaches. Frameworks such as Design thinking helps students to test assumptions and learn from their mistakes in a low-risk environment through iterative prototyping and feedback loops. These frameworks provide structured yet flexible methods that foster innovation, empathy, and critical problem-solving across educational levels and disciplines. Evidence further indicates that effective integration of DT enhances innovation and supports the development of patent-aware, user-centred designs when implemented with an appropriate capacity, contextual adaptation, structured IP education, and robust assessment. Eventually, the difference in outcomes reflects contextual diversity, which highlights the importance of carefully designed methodologies when fostering patentable innovation.

Design Thinking process encourages the identification of deep needs and problems, translating these insights into tangible, valuable designs that can lead to innovative and potentially patentable outcomes. Primarily, Design Thinking enhances creativity and innovation by structuring a cognitive practice aimed at uncovering profound user needs and converting them towards innovative solutions, by placing the user and their experiences at the core of the design process, innovations generated are more likely to meet real-world demands, increasing the chance of developing unique and effective products that can qualify for patents [8].

Additionally, Design Thinking fosters a culture of continuous problem identification and collaborative design, which is essential in sustaining innovation within higher education organisations. The iterative nature of DT characterised by stages such as understanding, observation, ideation, prototyping, and testing; helps teams refine ideas actively, thus improving the novelty and functionality of designs that enhance their patentability. This process allows students to develop original product designs and document their process systematically, which is critical for patent applications.

Design Thinking relatedly supports innovation through its role in active learning and motivation toward sustainable design. For example, in engineering education, embracing DT traits like integrative feedback and collaboration has been shown to motivate students to tackle sustainability challenges creatively, promoting innovative design solutions with potential for real-world applications and intellectual property creation [9]. This educational foundation prepares students for innovation that can be protected through patents.

To conclude, it is only fair to confirm that Design Thinking can confidently drive innovation by promoting a structured, human-centric approach that nurtures creativity and iterative improvement. It enables teams and individuals to develop original, user-centred solutions that address real needs, incorporates mechanisms to protect intellectual property early, and exploits supporting technologies that enhance creative processes. This comprehensive approach increases the likelihood that design outcomes will not only be innovative but also patentable, thereby advancing traditional, linear design processes and proposing competitive advantages. However, despite this potential, the systematic integration of DT in design education to intentionally support the production of patentable solutions remains limited.

3 METHODOLOGIES

3.1 Research Design

This study adopts a practice-based educational intervention approach to examine the integration of Design Thinking (DT) with structured intellectual property (IP) processes within senior-level design studio courses that may lead to potentially patentable outcomes. The study is exploratory in nature, focusing on assessing the feasibility and educational potential of integrating IP-focused practices into design pedagogy rather than to establish causal relationships. The intervention was implemented within real course settings, allowing observation of both the process and outputs of student work. It was conceptually structured around four interconnected stages, i.e. IP literacy, Design Thinking Process, Intellectual Property integration, and finally leading to the project outcomes as illustrated in Figure 1.

Figure 1. Design-process for IP-focused outcomes

3.2 Context and Participants

The study was conducted within undergraduate Industrial Design and Interior Design programmes at the College of Design, through two separate practice-based courses: an Industrial Design Elective course and a senior Interior Design Studio course. Both courses were delivered over a single 15-week academic semester and included a major project-based assignment that integrated design development with intellectual property (IP) considerations, encouraging students to move beyond creative ideation toward potentially patentable innovation. Although both cohorts followed the same overarching framework, which combined design thinking with IP screening and protection processes, they worked on discipline-specific project briefs aligned with their programmes.

Participants comprised a total of 48 undergraduate senior students (final year), organised into teams of two to four students per project. The only participation criterion was being enrolled in the course. While all students had baseline experience with design briefs and prior exposure to selected DT phases, their familiarity with DT and IP varied across cohorts, as Industrial Design students had prior exposure to patent literacy and the application process, whereas Interior Design students encountered structured IP screening for the first time within this project.

3.3 Intervention and Screening Process

The intervention was implemented across two practice-based courses independently, both courses adopted a Design Thinking (DT) instructional approach. DT stages, i.e. empathy, problem definition, ideation, prototyping, and testing, structured the project process as an underlying pedagogical framework. Intellectual Property (IP) and patent application were formally introduced in both courses by the College's Innovation Unit Representative, establishing key aspects of patentability criteria, prior art considerations, and submission procedures.

In parallel, projects underwent structured screening for patent potential at key stages of development. This included reviewing project viability, preparing required documentation, completing application forms, and coordinating formal submission procedures. All processes were overseen by the Innovation Unit, ensuring consistency in evaluation, compliance with institutional and legal requirements, and alignment between academic outputs and patent application standards.

3.3.1. Duration and Project Timeline

The intervention spanned approximately 15 to 20 course-hours over a period of 5 to 6 weeks, covering the full project cycle from ideation to submission of the patent application files through the university Patent and Technology Transfer Office (PTTO).

Following a timeline aligned with DT stages, the project began with Phase 1 (3 hours), which focused on IP literacy, followed by Phase 2 (3–6 hours), involving ideation and concept development alongside an introduction to patent application processes and prior art exploration. Phase 3 (3 hours) included low-fidelity prototyping and iterative testing, while Phase 4 (3–5 hours) focused on the final design development and presentation, including faculty review of patent application drafts. The process concluded with Phase 5 (3 hours), which involved the compilation of project documentation and the submission of preliminary patent applications for eligible projects to the university PTTO, including the required forms and supporting materials such as all drafts, presentations, technical drawings, and rendered images.

3.3.2. Supporting Tools and Resources

1. **IP literacy workshops and expert feedback:**
   Workshops delivered by the faculty liaison with the PTTO introduced patentability criteria, prior art search strategies, and basic patent drafting. Additional support was provided by internal IP consultants and external mentors from the Industrial Design Department, offering feedback on novelty and industrial applicability to Interior Design teams.
2. **Patent databases:**
   Prior art searches were conducted using free and institutional patent databases such as WIPO-Patent-scope, Google-Patents, and USPTO, with guidance on search procedures and disclosure form completion provided by course coordinators.

3.3.3. Patent Screening Process

During the design development and refinement stage, both formative and summative assessments were integrated to support student learning and strengthen the patent potential of the proposed concepts. Evaluation was conducted through continuous discussions, iterative reviews, and formal assessment activities. Formal evaluations were guided by structured rubrics assessed key criteria, including design concept and impact, innovation, feasibility, and overall development quality.

Following the initial screening, projects underwent an additional review by the College Innovation Unit to ensure the completeness of documentation, drawings, and required forms. Subsequently, submissions were forwarded to the PTTO for final evaluation of the application, including compliance checks and assessment of submission quality, afterwards, projects were either accepted for further processing or received preliminary approval i.e. "green light."

This multi-stage screening process (Figure 2) functioned both as an evaluation filter and a learning mechanism. It guided students in refining their concepts toward more viable, well-documented, and potentially patentable outcomes.

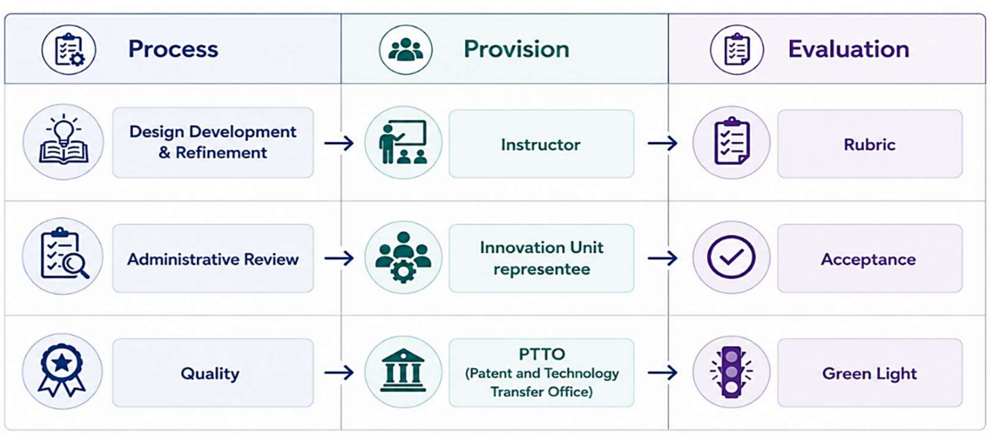

Figure 2. Reviews and evaluations

4 PROJECT OUTCOMES

A total of 16 projects were submitted to the PTTO for patent consideration (8 by Industrial Design, and 8 by Interior Design), thus far (4 months after courses' completion), five projects have received preliminary approval, i.e. "green light" by the PTTO office and moved forward to the preparation for the next stage, i.e. "filing stage" in addition to two projects that actually progressed to the formal patent filing (Figure 3).

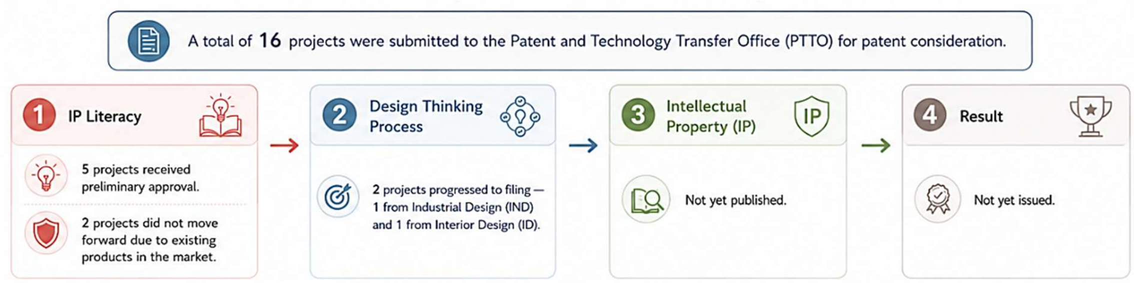

Figure 3. Projects' outcomes

5 DISCUSSIONS OF OUTCOMES

The integration of DT within the two practice-based courses yielded measurable academic and innovation-oriented outcomes. Students demonstrated enhanced capability in performing user-centred problem definitions, generating concepts grounded in empathy findings, and developing designs supported by professional feedback.

Compared to prior cohorts (before the structured DT integration), project documentation reflected greater clarity in problem framing, stronger justification of design decisions, and more systematic iteration processes. A key outcome of the intervention was the increased awareness and consideration of intellectual property (IP) dimensions during the design development phase. By introducing patentability criteria, students shifted from producing conceptually strong but academically confined projects toward solutions positioned within real-world innovation ecosystems.

Several projects were screened for patent potential, and a subset progressed to formal application procedures. This demonstrates a tangible shift from design as an academic deliverable to design as a protectable innovation asset.

The structured exposure to the patent application process further contributed to students' understanding of innovation beyond ideation. Engagement with prior art searches, documentation requirements, and formal submission procedures strengthened analytical rigor and critical comparison skills. Students were required to defend the uniqueness of their concepts relative to existing solutions, which deepened their strategic thinking and reduced superficial novelty claims. This alignment between DT and patent evaluation criteria appears to have reinforced the practical dimension of innovation competence.

From a pedagogical perspective, embedding IP processes within practice-based courses reduced the traditional separation between creative exploration and commercialisation pathways. Rather than treating patenting as a post-graduation activity, the intervention positioned it as an integrated component of design development. The consistency of implementation minimised procedural variability and ensured alignment between educational objectives and innovation outcomes.

However, the findings also reveal challenges. Not all high-quality design projects demonstrated patentable potential, underscoring that creativity alone does not guarantee protectable innovation. Additionally, the patent screening process required substantial faculty involvement, raising concerns about scalability in larger cohorts. This could be addressed by standardising IP literacy before project initiation, for example through recorded lectures, and by partially automating the screening of non-confidential IP related sections using tailored AI tools. These tools could also support longitudinal tracking and help monitor the long-term commercial potential of the projects.

Despite these constraints, the outcomes suggest that structured integration of DT with explicit patent education can meaningfully enhance students' innovation literacy and increase the likelihood of generating patent-oriented design outputs.

6 CONCLUSIONS

The proposed pedagogical framework contributes to design education by linking creativity, feasibility, and protectability within a single instructional model. It positions academic practice-based courses as early-stage innovation incubators and demonstrates the value of integrating IP literacy into design curricula.

The framework also shows potential for adaptation across other practice-based disciplines seeking to enhance innovation-oriented outcomes.

Future efforts should focus on scaling the model through institutional support mechanisms, interdisciplinary collaboration with legal and technology transfer units, and longitudinal tracking of commercialisation outcomes. Further multi-institutional research is recommended to validate and refine the framework across diverse educational contexts.

DECLARATION

During the preparation of this manuscript, ChatGPT was used solely for proofreading and improving sentence clarity and readability. The authors reviewed and approved all edits and remain responsible for the manuscript's content.

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