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CONVERGENCE IN DESIGN EDUCATION: INTEGRATING THE "THREE BLENDING AND INTEGRATION" MODEL WITH NSF'S CONVERGENCE RESEARCH FRAMEWORK

XiaoChao XI[1], Yang MA [1]
[1]Beijing University of Posts and Telecommunications, China

ABSTRACT
Design education is increasingly challenged to address complex societal problems in an era of rapid technological change, particularly with the rise of artificial intelligence. Traditional single-discipline approaches are insufficient, educational models must foster deep interdisciplinary collaboration and integration across fields. This paper presents a comprehensive exploration of cross-disciplinary convergence in design education by integrating two paradigms the "Three Blending and Integration (TB&I)" mechanism developed and the U.S. National Science Foundation's Convergence Research framework. Theoretically we discuss how convergence of disciplines as conceptualized by NSF and the TB&I mechanism both emphasize breaking down silos uniting technology and aligning education with real-world problem solving; we then provide a detailed case study of a postgraduate design education reform, illustrating how the TB&I mechanism is implemented in practices. The case study highlights interdisciplinary curriculum structures project-based learning via pre-research industry projects and robust "industry, education, research integration" that together produced notable outcomes in innovation and talent development.

Keywords: Convergence Research, Design Discipline, Postgraduate Education, Interdisciplinary Collaboration

1 INTRODUCTION

Contemporary design education stands at a crossroads of opportunity and responsibility. The rapid advancement of artificial intelligence is profoundly reshaping disciplines, demanding that design professionals possess not only creative and artistic expertise but also technical acumen. This recognition has led to a growing emphasis on convergence of disciplines in education, aiming to produce graduates capable of interdisciplinary innovation. In U.S., the National Science Foundation (NSF) has elevated Convergence Research as a priority framework for tackling "vexing research problems" focused on societal needs [1]. Convergence Research posits that today's grand challenges will not be solved by one discipline; instead, deep integration of knowledge, methods, and expertise across fields is required, centered around specific complex problems [2-3]. However, achieving such integration often requires rethinking educational structures and overcoming barriers in traditional academia [4].

Bring this framework to design postgraduate education, we propose a "Three Blending and Integration (TB&I)" mechanism. This model is devised in response to three core challenges identified in design talent training amid the AI era: (1) inadequate fusion of technology and design education with traditional curricula stuck in knowledge transmission rather than capability cultivation. (2) misalignment between academic training and fast-evolving AI industry needs, leading to gaps between teaching and real-world application; and (3) insufficient support for nation's "AI+" strategic needs, creating an urgency to train pioneering leaders for unexplored "uncharted territories" of AI [5]. To tackle these issues, we develope the TB&I mechanism, which uses digital-intelligence tools at its core and fully embeds cross-disciplinary, cross-sector integration into the teaching process [5]. This mechanism represents a dual focus: "Three Blending (TB)" connect disciplinary domains, academia with industry, and teaching with learning; "Three Integration (TI)" joins teaching with learning, practicing with researching, and supply with demand in talent pipeline [5]. In essence, it strives to infuse every aspect of education with interdisciplinary collaboration and practical relevance, while ensures educational outcomes to meet societal and industry needs [6]. By establishing this mechanism, we aim to create a "stereoscopic accelerator" for talent development, one that leads in thought, drives social impact, and improves human well-being [5] that is vital for training designers as change agents in an AI-driven, interconnected world.

2 CONVERGENCE OF DISCIPLINES IN DESIGN EDUCATION

2.1 Convergence Research as a Framework

The NSF defines convergence research as a novel mode for solving complex problems that "focus on societal needs," characterized by two primary features: (1) being driven by a specific, compelling problem, and (2) involving deep integration across disciplines, where researchers from diverse fields jointly develop new shared frameworks, methods, and languages [2]. This concept has been heralded as a paradigm shift beyond traditional interdisciplinary approaches. The convergence requires a more profound synthesis – often bringing together fields that historically have not interacted – and an explicit orientation toward translational outcomes and societal impact [7-8]. In fact, convergence is often likened to transdisciplinary research taken to its highest integration, merging knowledge to the point that new hybrid disciplines or frameworks may emerge [9]. Crucially, convergence projects do not arise spontaneously; they demand deliberate strategies to overcome cultural and organizational barriers between disciplines[10]. NSF notes that outdated educational approaches and rigid structures can hinder integrative research progress [4], underscoring the need for educational innovation to prepare a convergence-capable workforce.

NSF's emphasis on convergence is reflected in its programs and criteria for success. One of NSF's "10 Big Ideas" in recent years is Growing Convergence Research, aimed at spurring researchers from disparate fields to coalesce around tackling grand challenges [11]. The agency has also launched the Convergence Accelerator to provide intensive training and mentoring to multidisciplinary teams translating research into practical solutions [12]. According to NSF, successful convergence initiatives typically exhibit: a compelling need for an integrative approach, readiness and diversity of the team, novel integration of knowledge and methods, and involvement of next-generation researchers [1]. Notably, NSF explicitly encourages projects to offer a "model learning environment" for students and early-career researchers [1]. This aligns with the idea that convergence is not only a research paradigm but also an educational one – requiring new ways of teaching and learning that break disciplinary boundaries.

In the context of design education, convergence has special resonance. Design is inherently a field that straddles multiple domains: it blends artistic creativity, technological know-how, and understanding of human behavior. Recent literature has pointed out that while convergence research efforts often focus on STEM integration, "full convergence also necessitates inclusion of social sciences and humanities to address the human and societal dimensions of complex challenges [1]." Design as a discipline, embodies this integration by drawing on social science foundations, applied arts, and a future-oriented, problem-solving mindset. Scholars have observed that design is gaining attention at NSF as a means of grounding research in human experience and enabling cross-disciplinary collaboration. However, the role of design in convergence is still emerging and not yet fully recognized, indicating untapped potential for design education to contribute to convergent science and innovation [3].

2.2 "Three Blending and Integration" Mechanism

In the early 2025, Chinese higher education policymakers have promoted interdisciplinary integration and industry-education collaboration as national strategies. *The Education Powerhouse Development Plan (2024–2035)* explicitly calls for strengthening the synergy of science/technology education with humanities education, and launching an "interdisciplinary discipline breakthrough plan" to build joint innovation platforms among universities, enterprises, and local regions. This policy backdrop has encouraged universities to create new modes of cross-disciplinary talent development. The TB&I mechanism emerges from this context as a practical framework tailored to design-related fields. Its key components include "Three Blending (TB)" refer to: (1) blending of engineering, art, and liberal arts disciplines in curriculum and projects, (2) blending of academia, industry, and research through partnerships and practical projects, and (3) blending of teaching and learning processes by reforming how instructors, students, and external mentors collaborate. Meanwhile, the "Three Integration (TI)" indicates connecting: teaching with knowledge acquisition by students, collaborative doing (practice) with research (scholarship), and school training supply with societal/employer demand [6] (see Figure 1). In more concrete terms, this mechanism is designed to ensure that knowledge impartation is tightly linked to educational practice, that co-creation activities feed into academic scholarship, and that front-line industry guidance aligns with internships and job placement. By achieving these integrations, the mechanism aims to produce outcomes that have "ideological leadership, social impact, and improvement of people's livelihood", which are viewed as a three-dimensional acceleration of educational impact [5].

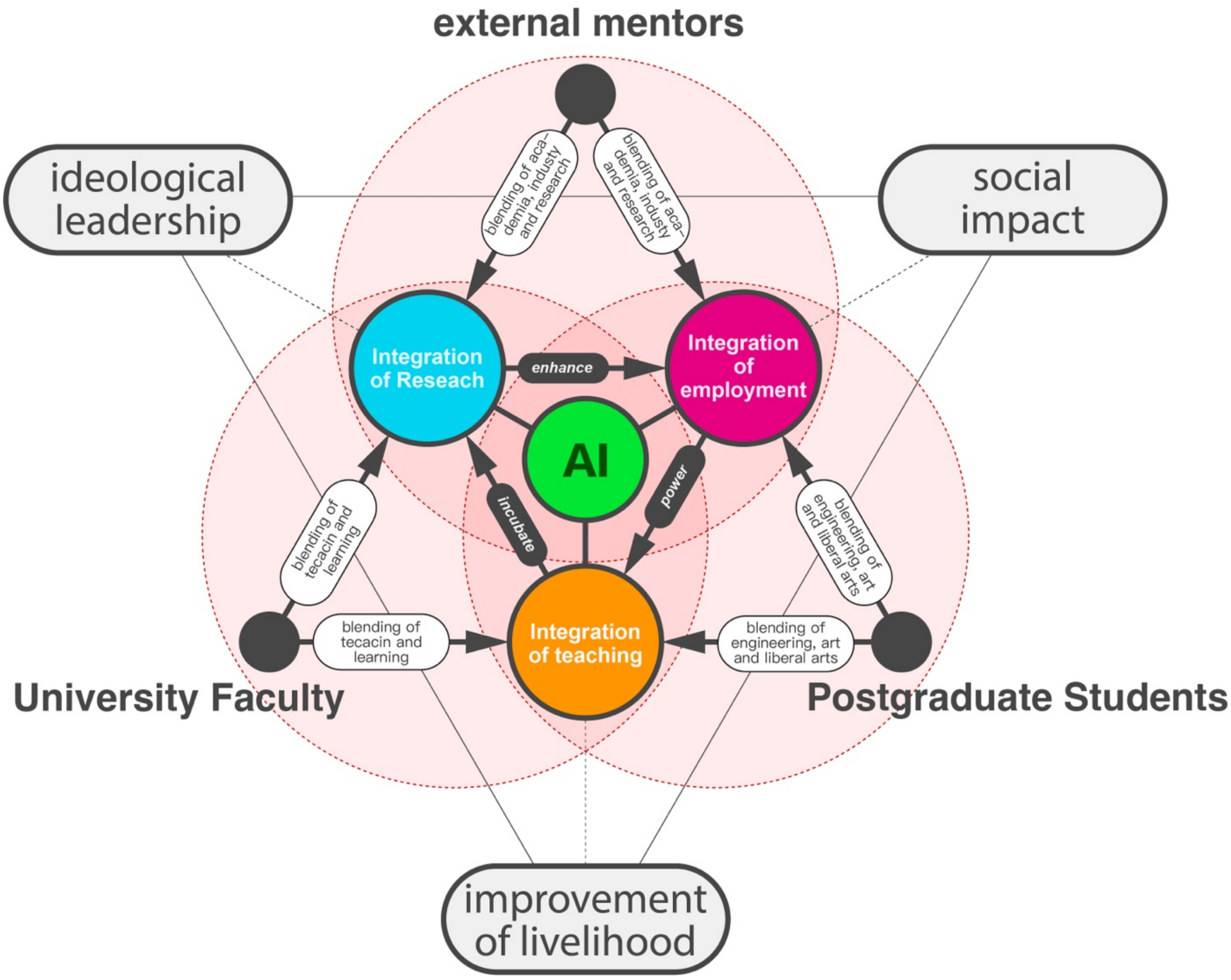

Figure 1. Mechanism of "Three Blending and Integration" model

At the heart of the TB&I mechanism is the principle of "discovering, researching, and solving real problems." Design of postgraduate curriculum is infused with real-world projects and societal challenges, that identifies three key tasks: intelligent media guiding publics (ideological leadership realization), science popularization activities shaping citizens' scientific literacy (social impact enhancement), and intelligent manufacturing improving people's well-being (livelihood improvement). Achieving such tasks require bridging the gaps between different disciplinary research methods: empirical data driven of engineering, divergent creative ideation of art, deductive reasoning and contextual analysis of liberal arts. This echoes convergence thinking: multiple lenses are needed for holistic understanding [3], and AI serves as a bridge to unite those perspectives.

Another innovative aspect of the mechanism is its localization of NSF's convergence concept into a "four-step educational approach." We use NSF's convergence as inspiration, crafting a pedagogical workflow to structure interdisciplinary collaboration (See Table 1). This four-step approach consists of: (1) Problem Anchoring, where a real-world problem is identified and framed (with activities like theoretical framing for engineers, inspiration for designers, literature review for humanities to ensure a well-rounded understanding); (2) Cross-Disciplinary Integration, where insights and methods from different fields are synthesized into a common approach or "common language" to address the problem; (3) Co-creation, Iteration and Testing, an iterative loop of prototyping and experimentation involving all disciplines to refine solutions; and (4) Paradigm Consolidation, where the solution or new framework is formalized and evaluated. By structuring collaboration in this way, the program provides a methodological pathway for multi-layered convergence, guiding students from different backgrounds (engineering, art, and liberal arts) to work together systematically from problem definition to solution implementation.

Table 1. Four-step educational approach

empirical, data-driven （Engineering）	**divergent, creative ideation** （art）	**deductive reasoning and contextual analysis** （liberal arts）	**Convergence Research (NSF)**	**Four-step approach**
Theoretical support	inspiration	literature review	problem anchoring	problem anchoring
experiment design	ideation	problem discovering		
		critical thinking	common language	cross-disciplinary integration
			cross-mapping between methods and data	
simulation	simulation		prototyping framework	co-creation, iteration and testing
test			co-creation, iteration and testing	
	implement	Theoretical construction	paradigm consolidation	paradigm consolidation

3 POSTGRADUATE DESIGN EDUCATION REFORM

3.1 Mechanism and Implementation

The TB&I mechanism is implemented through a combination of curricular innovation, organizational restructuring, and partnership building. At its core, the program established cross-functional "joint teams" as the basic operating unit of education. Each joint team typically comprised university faculty, external expertise from industry or government and a group of students (often with mixed disciplinary backgrounds). These teams are sustained partnerships oriented around a theme or problem domain. Between 2018 and 2025, we have formed 15 joint teams in collaboration with high-profile industry and public sector partners. For example, teams are established with *Xinhua* News Agency to explore AI-generated content for news media, the Palace Museum team on creative design training for cultural heritage.

To facilitate these collaborations, pre-research projects are brought in which refer to a project that has elements of exploratory research but is also grounded in implement. Essentially, a project that lies between academic research and product development. Once a project was defined, the team would move through the four-step co-creation cycle described earlier. For example, consider the collaboration with *Xinhua* News Agency's AIGC Studio, the question anchored might be "How can AI-generated imagery and video be used to enhance news storytelling while maintaining credibility?" Engineering students and faculty would contribute by developing or adapting AI models to create media content; design students would work on the visual and narrative design, ensuring the content is compelling and fits audience needs; communication students might study audience perception and the ethical guidelines for AI news content. Through iterative co-creation workshops, the team would prototype short AI-generated news clips or data-driven visualizations, test them, and refine their approach. The organizational layer of the mechanism clearly defines roles: university faculty provided knowledge instruction and guided students in applying AI techniques to solve problems; industry mentors provided domain-specific insights, standards, and feedback from a real-world perspective; and students were expected to take initiative, engaging in self-directed learning and research as they tackled tasks, thereby developing good academic and professional habits.

3.2 Interdisciplinary Curriculum and Project-Based Learning

Academically, the project reforms its curriculum to be more flexible and interdisciplinary. Traditional course silos are bridged through joint course offerings and elective modules that encourage students from different majors to learn together. In some cases, courses are co-taught by faculty from different disciplines or even co-developed with industry input. Back to the collaboration with AIGC Studio, a set of courses across undergraduate and graduate levels are built around the theme of AIGC animation design, answering the raised question. Courses such as *Creative Video Research* (in the Digital Media Art major), Media Convergence (in the New Media Communication major), *Design History* (in Intelligent Interaction Design Major), and *Chinese and Foreign Design History Research* (in the Design postgraduate program) are coordinated so that students from these classes form mixed teams to co-create animated works on an AI theme. This cross-course studio results in six outstanding animation pieces being published on *Xinhua*'s official platform (see Figure 2). This example demonstrates how the curriculum is structured, enabling a truly interdisciplinary project experience as part of coursework. In terms of talent development, the convergence-oriented reform succeeds in narrowing the gap between student skills and industry needs. Above all, the TB&I mechanism achieves a multifaceted success in practice. It produces better prepared graduates with hands-on experience and cross-domain skills, relevant research outputs and innovations through convergence projects addressing real needs, and broader societal contributions in media, education, and public services. These results exemplify how a convergence approach in design education can function as a "win-win:" benefiting students, academic faculty, industry partners, and society at large.

Figure 2. AIGC animation published on Xinhua's official platform

4 DISCUSSION

The TB&I mechanism shows how convergence concepts can be put into practice in design education. It demonstrates alignment with convergence frameworks and offers broader lessons. Key themes include problem-driven interdisciplinary collaboration, organizational innovation for integration, and infusion of AI technology.

4.1 Alignment with Convergence Research Principles

The TB&I mechanism closely mirrors the NSF's convergence research criteria. First, it is clearly problem driven. This exemplifies the convergence ideal of rallying diverse disciplines around a unifying problem [1]. Many projects addressed pressing societal needs, echoing NSF's emphasis on societal impact as a motivator for convergence [3,8]. Second, the program featured deep integration of disciplines. Rather than superficial cooperation, the joint teams practiced "strong coupling," co-developing methods across fields. For example, in the AIGC project with *Xinhua* agency, the engineering (AI modeling), design (visual storytelling), and communication (audience strategy) components are interdependent, which requires a shared framework for success. This level of integration fulfills the notion of convergence where new paradigms emerge from blended expertise [9]. Another convergence hallmark is involving next-generation researchers in an inclusive team culture. the TB&I mechanism puts postgraduate students on every project, treating education as part of the research process. Students aren't just absorbing knowledge; they were co-creating solutions alongside faculty and industry mentors. This reflects what NSF calls a "model learning environment" for convergence. Teams were intentionally flat (minimal hierarchy), aligning with convergence calls for horizontal collaboration, and students felt valued as equal contributors prepared for future convergent work.

4.2 Interdisciplinary Curriculum and Multi-Level Collaboration

A key outcome of the case is how curriculum design and organizational mechanisms enabled collaboration across disciplines, across theory and practice, and across university and industry. We essentially restructure its education to enable true interdisciplinary teamwork. It replaces isolated courses with project-centric learning across the curriculum. Courses are coordinated around joint projects so that students from different majors collaborate on a shared deliverable project, flatten academic silos and mirrored real-world interdisciplinary work. External mentors are embedded in these projects, bringing industry expertise into the classroom rather than relying only on off-site internships. This was a concrete realization of "industry, academia, research integration" that often advocated but rarely achieved.

4.3 Global and Cross-Cultural Reflections

Practice of the TB&I parallels U.S. convergence initiatives. For example, the NSF Multiscale RECIPES project for sustainable food systems integrated diverse disciplines via design methods, emphasizing "whole person" team engagement, much like TB&I mechanism [14]. Likewise, the NSF Convergence Accelerator assembles interdisciplinary teams to tackle real-world problems on fast timelines, mirroring our intensive mentor-guided project cycles.

4.4 Challenges and Considerations

Implementing convergence comes with challenges. It demands extra effort and broad skills. Students must step outside their comfort zones: design students learn coding and data skills, and engineering students engage in user research and design critique. Faculty also must coordinate across disciplines and co-teach, which required strong sense of cooperating with industry. Not every university has enough multi-skilled faculty or industry partners to do this initially. Moreover, convergent projects are often open-ended, which can clash with rigid academic timelines and grading. we use competitions and tangible deliverables to motivate and evaluate teams, but traditional grading still struggles to fairly assess diverse contributions. Sustaining partnerships also require ongoing effort, and we expand collaborations depended on active faculty liaisons and administrative support.

4.5 Implications for Broader Design Education

Courses from the TB&I mechanism have broad implications for design education. Embracing convergence means reimagining curriculum design – moving away from siloed courses toward interconnected, problem-centered learning experiences. Programs can center curricula on complex societal challenges, supplementing traditional courses with multidisciplinary projects. Even small projects prepare students for careers where they must collaborate with engineers, business experts, and other specialists. Likewise, industry and community projects can be woven into coursework (not just treated as internships) to create a living lab that bridges theory and practice. It shows that real-world, cross-disciplinary projects can spark innovation and give students invaluable hands-on experience.

The TB&I mechanism with NSF's convergence framework further yields clear benefits. It validates convergence theory with outcomes: students adept in multiple domains, projects yielding scientific insights and societal value, and a curriculum agile enough to keep pace with rapid technological change. Different institutions may implement such models on varying scales, but the core principles—problem focus, deep integration, partnerships, and iterative co-creation—are widely applicable. As design education faces the challenges of AI, sustainability, and globalization, a convergence approach that combines technical rigor and real-world engagement will be crucial for preparing designers to be not only creators, but also innovators and leaders. Such graduates will be ready to tackle the "wicked" problems, armed with the holistic perspective and collaborative experience that embody convergence.

5 CONCLUSION

This paper has explored the integration of the "Three Blending and Integration (TB&I)" cross-disciplinary talent training model with the NSF Convergence Research framework, articulating both theoretical and practical dimensions of convergence in design education. The theoretical discussion established that both frameworks converge on common principles: breaking down disciplinary silos, focusing education and research on real-world complex challenges, and fostering deep collaborations that unite technology and human-centric approaches. Convergence research, as championed by NSF, provided a vocabulary and set of criteria for what it means to truly integrate disciplines in pursuit of societal impact [2,7]. The TB&I mechanism demonstrates how similar ideals can be embedded in an academic project, ensuring that teaching, research, and application are interwoven to produce graduates who are adept in multiple domains and attuned to industry and societal needs [6].

The case study serves as a concrete embodiment of these ideas. And we see a systematic reform that implemented convergence: interdisciplinary curricula, joint industry-academia teams, project-based learning anchored in AI-driven societal projects, and multi-stakeholder mentorship. The outcomes – from increased student innovation and employability to new research outputs and societal initiatives – underscore that a convergence-oriented educational model can significantly enhance both learning and impact. This validates the notion that convergent education is particularly powerful in the context of emerging technologies: it prepares students to be not just consumers of technology trends but shapers of technology for social good.

We assert that the convergence of disciplines in design education is not only an abstract ideal but an attainable reality – one that is being realized through innovative models like the TB&I mechanism. By blending engineering, art, and humanities, and integrating the efforts of universities, industries, and communities, design can become crucibles for convergent innovation. Graduates from different disciplines will be uniquely equipped to lead in addressing complex challenges: they will have the technical savvy to harness AI and other advanced tools, and the collaborative experience of working in diverse teams towards common goals. As the world faces increasingly intertwined challenges that do not fit neatly in one domain, the need for convergence-oriented thinkers and doers will only grow. Design education, with its bridging capacity between technology and humanity, can take a forefront role in this educational transformation. The integration of frameworks explored in this paper offers a blueprint for how to educate the next generation of designers as convergence leaders. It is our hope that the insights and evidence provided here inspire further experimentation and adoption of such mechanism globally, ultimately contributing to an international movement toward convergence in higher education for the betterment of society.

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