

## **Fostering Interdisciplinary Talent Through Cross-Disciplinary Project-Based Learning: A Case Study From a Japanese National University**

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### **Abstract**

This study examines a cross-disciplinary education model implemented at a Japanese national university, targeting graduate students through Project-Based Learning (PBL). The program emphasizes addressing social issues and exploring diverse career pathways in academia, industry, and government. This presentation outlines the program's background and design, reviews implementation outcomes over the past 12 years, and evaluates its impact on cultivating interdisciplinary talent within Japan's higher education context. The program offers original courses, long-term project-based learning opportunities, and both group and independent practical activities. Drawing on expertise from all graduate schools and involving faculty members from diverse fields in both program management and teaching, the curriculum equips students with essential skills in problem identification, problem-solving, and social engagement. It encourages students to play active roles across disciplines beyond their own specialization, fostering innovative thinking and responsiveness to complex societal challenges. Over the past 12 years, more than 170 graduate students—including many from international backgrounds—have participated in the program. Follow-up surveys indicate that most graduates secured employment across a wide variety of fields, often beyond the direct scope of their graduate research. Many alumni have launched unconventional career paths for PhD holders, highlighting the program's success in enhancing the employability of doctoral graduates and fostering interdisciplinary talents who can adapt to the rapidly evolving demands of society and industry.

*Keywords:* cross-disciplinary education, graduate student, project-based learning, social issues, Japanese university

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## Introduction

In many countries, the number of PhD graduates (PhDs) now exceeds the number of available academic positions, making access to professorships highly competitive (OECD, 2024). Universities face growing pressure to rethink doctoral education. They are urged to equip graduates with the knowledge and skills needed for diverse types of jobs (OECD, 2021). As traditional academic pathways narrow, the need for reform in doctoral education systems becomes increasingly urgent to ensure that graduates can thrive in both academic and non-academic career environments.

Graduate employability is critical for professions and industries, many of which are experiencing crippling talent shortages that impede organizational and sector-wide productivity. Alongside the economic gains from high-performing graduates, developing rounded, socially responsible citizens is also critical for global wellbeing (Bennett, 2019). The alignment between doctoral education and labor market demands thus plays a central role not only in addressing economic challenges but also in contributing to societal resilience and development.

For students pursuing doctoral and higher-degree studies, engaging in interdisciplinary research provides numerous benefits (Vanstone et al., 2013). It broadens intellectual horizons, equips students with a versatile skill set, and prepares them for a wide array of career paths (Rana et al., 2025). Employers value the unique perspectives and problem-solving skills that interdisciplinary researchers bring to their organizations (Miller & Boix-Mansilla, 2004). At the University of Osaka, interdisciplinary approaches are increasingly emphasized as an integral part of doctoral training to cultivate innovation and adaptability among researchers.

Extra- and co-curricular activities can further support employability by broadening social and professional networks, aiding career planning (Jackson & Bridgstock, 2021; Jackson & Tomlinson, 2022), and developing transferable skills (Buckley & Lee, 2021; Dickinson et al., 2021; Jackson & Cameron, 2025). These activities complement academic learning, enabling doctoral students to acquire the soft skills and professional awareness essential for navigating complex career landscapes.

However, scoping reviews on interdisciplinary education and the career trajectories of PhD students have so far largely relied on English-language sources (Rana et al., 2025; Skakni et al., 2025; Vanstone et al., 2013). This indicates a gap in the literature concerning non-English contexts and calls for broader comparative research that includes diverse linguistic and cultural perspectives to better understand the global dynamics of doctoral employability and interdisciplinary learning.

### **Cross-Disciplinary Education in Japan's Higher Education Context**

In the Japanese context, academic jobs are losing popularity due to uncertain career prospects (Arimoto et al., 2019), which may drive away talented students. The long-standing poor career prospects of Japanese academics are particularly noteworthy, as they have likely influenced Ph.D. progression in terms of students' motivations and career decision-making (Yoshioka-Kobayashi & Shibayama, 2023). This situation underscores the challenges faced by universities in sustaining interest in academic careers among highly capable students.

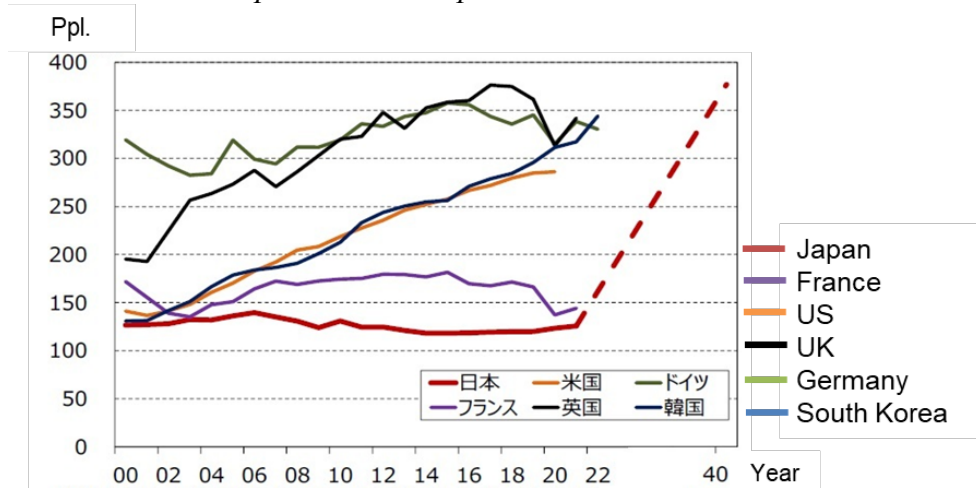
In Japan, the number of individuals pursuing doctoral degrees has shown a long-term decline. While enrollment in doctoral programs has exhibited a modest recovery over the past two years, it remained on a downward trajectory between 2003 and 2022 (Shuji Kawagishi, 2025). This decline reflects broader structural and societal issues, including limited academic employment opportunities and changing perceptions of the value of doctoral education. For institutions such as the University of Osaka, addressing these trends requires reexamining the role of doctoral education in fostering employability and creating diverse pathways for Ph.D. graduates beyond academia.

**Figure 1**  
*Number of Students Enrolling in Doctoral Programs*



Source: Shuji Kawagishi, 2025

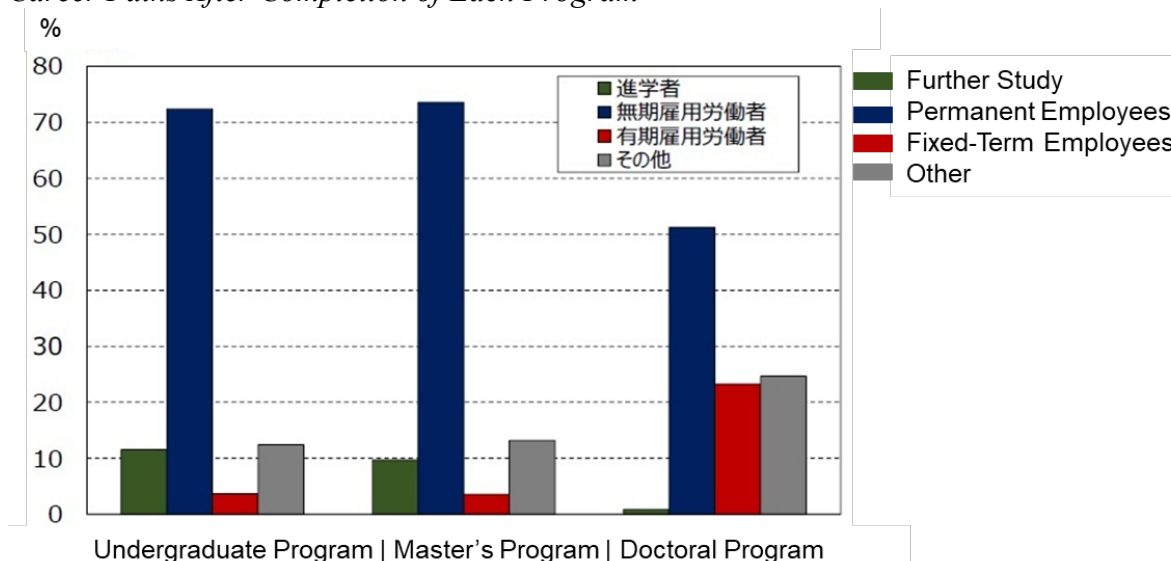
**Figure 2**  
*Doctorate Holders per Million People*



Source: Shuji Kawagishi, 2025

Students’ financial circumstances during their studies, combined with the uncertainty of their future career trajectories, constitute significant factors that discourage progression to doctoral programs. In addition, compared with graduates of undergraduate and master’s programs, those holding doctoral degrees face a substantially higher incidence of fixed-term employment, highlighting the unique career challenges encountered by this group (Shuji Kawagishi, 2025).

**Figure 3**  
*Career Paths After Completion of Each Program*



Source: Shuji Kawagishi, 2025

### Recent Policy Background in Japan

In the early 2000s, postdoctoral employment and career outcomes became a policy focus in Japan due to a decline in academic job opportunities and increased attention to the professional status of doctoral graduates (S. Kobayashi, 2011). By the mid-2000s, the Central Education Council reformulated faculty ranks and doctoral training systems to support younger academics and broaden academic career pathways (MEXT, 2006).

From 2012 to 2018, the Leading Graduate Program (MEXT) and the WISE Program (Doctoral Program for World-leading Innovative & Smart Education) were introduced. These initiatives funded integrated five-year doctoral tracks with an emphasis on interdisciplinarity, industry-academia-government collaboration, and the development of global skills (MEXT, 2019, 2023). In the 2020s, policy efforts have focused on enhancing financial support, such as the SPRING program, strengthening career services, implementing quality assurance reforms, and promoting internationalization, all aimed at better aligning doctoral education with societal and labor market needs (MEXT, 2024).

### Case Study

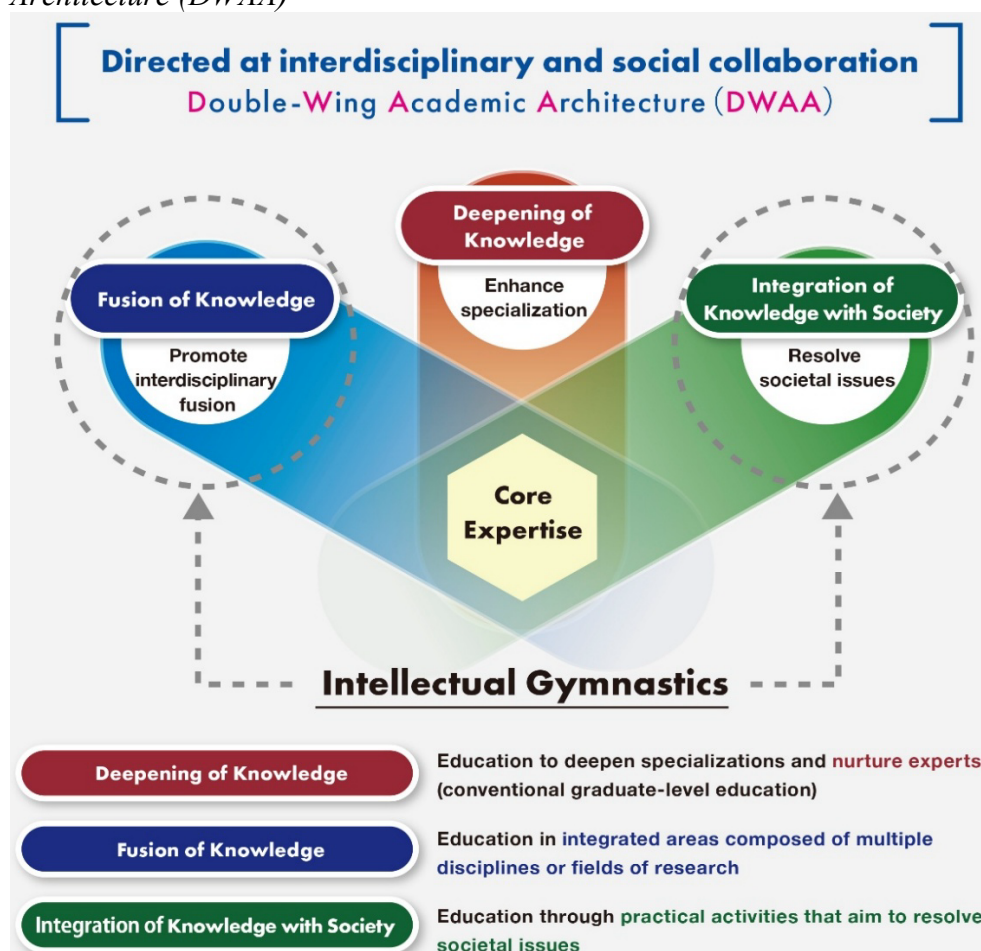
This paper presents a case study examining how cross-disciplinary education can enhance the employability of doctoral graduates and cultivate interdisciplinary talents capable of adapting to the rapidly evolving demands of society and industry. The study focuses on cross-disciplinary education at a national university in Japan, the University of Osaka, and explores the program’s background and design, the outcomes achieved, the challenges encountered and discusses future directions for such educational initiatives.

Since 2021, the University of Osaka has been promoting the Double-Wing Academic Architecture (DWAA), an advanced graduate education system focused on interdisciplinary and social collaboration. Its goal is to nurture doctoral professionals who can create social innovations across many fields, not limited to academia. DWAA is composed of three areas: Deepening of Knowledge, Fusion of Knowledge, and Integration of Knowledge with Society.

In addition to developing expert knowledge, the system expands education in two new directions predicated on the acquisition of core expertise. Graduate degree holders are expected to tackle problems with flexibility and a broad worldview, collaborate with diverse stakeholders, and leverage their core expertise as they more broadly and deeply apply their graduate school education.

#### Figure 4

*Structure of Graduate Education at the University of Osaka—Double-Wing Academic Architecture (DWAA)*

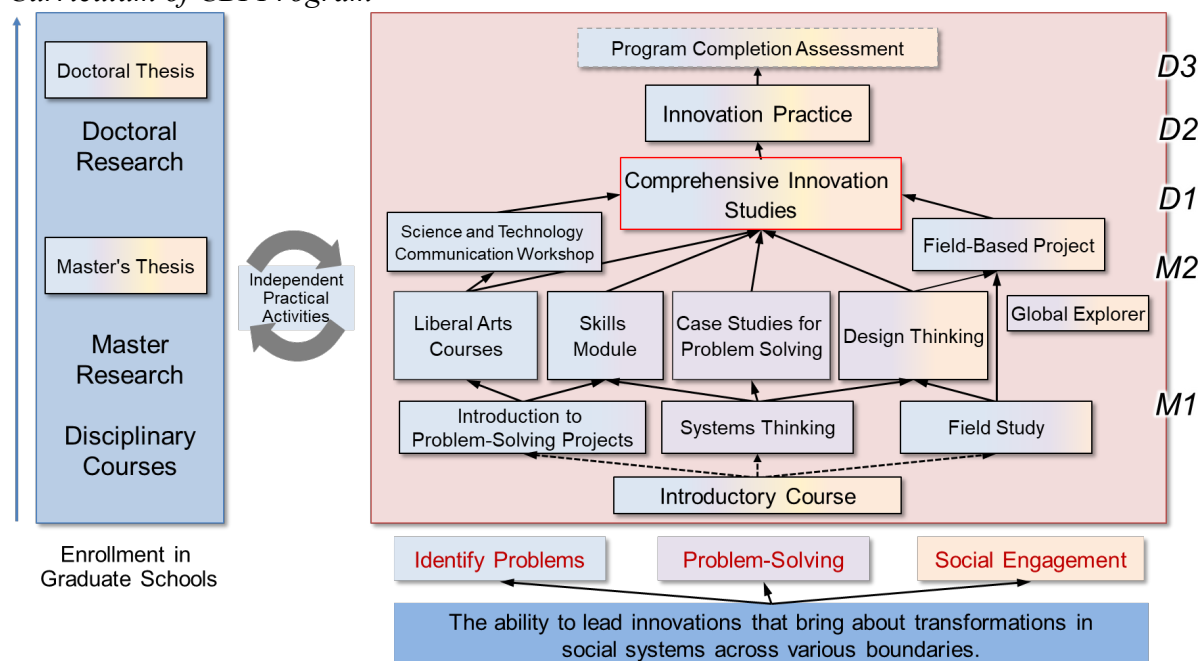


Source: <https://itgp.osaka-u.ac.jp/en/systems/dwaa/>

The Cross-Boundary Innovation Program (CBI Program) is an all-round cross-disciplinary graduate program that started in 2012. In this program, graduate students and faculty from all graduate schools of the University of Osaka come together around the main theme of addressing social issues, with classes and project-based learning offered to graduate students from both the humanities and the sciences. The program aims to cultivate a new type of doctoral talent who can play active roles across various fields beyond their specialization and supports diverse career paths in academia, industry, and government. From 2012 to the 2024 academic year, more than 190 graduate students from all graduate schools have participated in the program, covering a wide range of disciplines, including Human Sciences, Engineering, Humanities, Medicine, Sciences, International Public Policy, Biosciences, Pharmaceutical Sciences, Informatics, Law and Politics, Engineering Science, Economics, and Dentistry. Faculty members from all graduate schools, with diverse backgrounds, are also involved in program management and teaching.

The program offers original courses, long-term project-based learning, and both group and independent activities. Through these, students develop skills in finding and solving problems and in social engagement, while working beyond their own specializations to foster innovative thinking. Key features include workshops and project-based learning where students from different backgrounds and years can have constructive discussions, as well as overseas experiences and projects with companies and government agencies to find and solve social issues.

**Figure 5**  
Curriculum of CBI Program



Source: <https://www.cbi.osaka-u.ac.jp/teaching/feature/>

Independent Practical Activities (Jishu Jissen Katsudō) are initiatives planned and carried out by students themselves, allowing them to apply the knowledge and skills they have acquired in real-world social settings and to develop integrated, comprehensive abilities. Through these activities, students can plan and implement volunteer projects, internships, joint research, or other practical tasks aligned with their interests or expertise. So far, more than 70 students have participated in these activities. Between 2015 and 2024, students engaged with universities, research institutes, NPOs, companies, and government agencies. They organize these activities using networks provided by their supervisors, the program, or their own connections.

As an example of the Independent Practical Activity, a graduate student from the Graduate School of Frontier Biosciences developed a business model for sustainable medical aromatic essential oils. Drawing on prior nursing experience and recognizing the limits of conventional care, the student focused on aromatherapy. The objectives were to explore medical applications and develop sustainable, socially implementable models that support cognitive function and complement lifestyle disease and dementia care. Practical activities included upcycling by-products in Japan to reduce environmental impact, combining traditional cultivation with ecosystem restoration in France, and utilizing synthetic fragrances with data-driven production optimization in Switzerland. The next steps involve conducting empirical studies and establishing a sustainable supply model in collaboration with industry and medical partners.

The curriculum equips students with essential skills in problem identification and resolution, as well as social engagement, through courses and activities designed to support both individual and collaborative work. From the perspective of the KSAO model (Knowledge, Skills, Abilities, and other characteristics), students develop through three stages. In individual work, they acquire foundational and specialized knowledge, analytical skills, and problem-identification abilities, while fostering integrative thinking, curiosity, and motivation. In group work, students co-create with peers from different fields and collaborate with real-world partners, developing communication, teamwork, and collaborative problem-solving skills, along with flexibility, adaptability, and openness. In upgraded individual work, students apply cross-disciplinary insights to complex societal challenges, building advanced problem-solving, social engagement, and project management skills, while cultivating independent application, innovation, confidence, responsibility, and a reflective mindset. Further observation and analysis at each stage are needed, which will remain an ongoing goal for the future.

**Table 1**  
*Objectives and Benefits*

	Knowledge	Skills	Abilities	Other Characteristics
<b>Individual Work:</b> Exposure to multiple disciplines through course contents	Foundational & specialized knowledge	Analytical, problem-identification	Integrative thinking	Curiosity, motivation
<b>Group Work:</b> Co-creation with students from different fields & engagement with real-world partners	Peer knowledge across disciplines	Communication, teamwork, collaborative problem-solving	Flexibility, adaptability, synthesis of multiple perspectives	Teamwork, openness
<b>Upgraded Individual Work:</b> Apply cross-disciplinary insights to complex societal challenges	Integrated knowledge, cross-disciplinary insights	Advanced problem-solving, social engagement, project management	Independent application, innovation	Confidence, responsibility, reflective mindset

Over the past 12 years, more than 170 graduate students, including several international students, have participated in the program. Most graduates found employment across a wide range of fields, often beyond their research areas, with many pursuing unconventional career paths, demonstrating the program's success in enhancing employability and fostering interdisciplinary talents. Over half of the graduates (51%) entered the private sector, a figure significantly higher than the national average of 34%, while others took administrative or strategic roles. Among the 22 students aiming for academic careers, 18 secured full-time faculty or researcher positions, and the remainder became postdoctoral or part-time researchers. Returning to our research question—how does cross-disciplinary education enhance employability and foster interdisciplinary talents?—we note that doctoral employability involves a combination of knowledge, skills, attributes, social resources, and personal agency, enabling doctorate holders to secure, sustain, and advance in meaningful work both inside and outside academia throughout their careers (Jackson & Michelson, 2015; Pham, 2023). These outcomes clearly demonstrate the effectiveness of the program in achieving its objectives.

## Challenges

The program faces several challenges. High turnover of faculty and staff has affected continuity, consistency in teaching, and long-term relationship building with students, while also increasing the burden of recruitment and training for new members. Integrating multiple disciplines makes curriculum design complex, requiring ongoing adjustments to balance depth and breadth, maintain coherence, and respond to student needs and evolving societal and industry demands.

Currently, all courses are taught in Japanese, and the number of international students is very limited, restricting opportunities for cross-cultural interaction and global learning. While the program provides a strong academic foundation, additional support may be needed to help students develop cross-cultural communication skills, multilingual abilities, and the global mindset essential for pursuing international careers. Evaluating interdisciplinary learning is also challenging, as it involves both disciplinary knowledge and cross-field skills such as critical thinking and collaboration. Continuous improvement relies on feedback to refine teaching and learning activities.

Another major challenge concerns students' workload and mental health. Existing research on doctoral students' well-being has consistently reported high stress levels (Kernan et al., 2011; Virtanen et al., 2017; Wyatt & Oswald, 2013), mental health concerns such as depression (Hyun et al., 2006; Pallos et al., 2005), and physical health symptoms, including upper respiratory infections (Juniper et al., 2012; Kernan et al., 2011; Pallos et al., 2005). In their social and personal lives, doctoral students also tend to experience difficulties maintaining relationships (Dabney & Tai, 2013; Wellington & Sikes, 2006) and participating in social activities (Juniper et al., 2012; Longfield et al., 2006) due to limited time, financial constraints, and reduced motivation. Balancing the demands of both individual and collaborative work alongside their primary research can be challenging, making effective time and workload management essential. Collaborating with peers from diverse academic backgrounds may also present difficulties in communication, reconciling different perspectives, and coordinating approaches. Nevertheless, these experiences provide valuable opportunities for interdisciplinary learning and personal growth.

## Conclusion and Future Directions

Cross-disciplinary education is increasingly recognized as essential, both globally and in Japan, for addressing complex societal and academic challenges. In this context, programs like CBI serve as effective hubs for cultivating interdisciplinary talents and enhancing doctoral graduates' employability by equipping them with diverse knowledge, adaptable skills, and the ability to respond flexibly to the rapidly evolving demands of society and industry.

There is a growing need for specialized training and education programs tailored to interdisciplinary research skills, encompassing not only technical competencies but also emotional, social, cultural, and contextual factors (Menken & Kestra, 2016; Rana et al., 2025). We now conduct student follow-up interviews to monitor their progress and have launched several new initiatives to support students both mentally and physically. As Sverdlik et al. (2018) note, understanding doctoral students' physical, psychological, and emotional well-being is key to capturing the challenges of graduate education. Looking ahead, a future aim could include developing additional initiatives and opportunities that promote cross-cultural interaction and global learning.

CBI maintains strong collaboration with industries and other non-academic stakeholders. As Skakni and Inouye (2023) suggest, future research could explore these stakeholders' perspectives to inform more targeted preparation, enhance onboarding and retention practices, and further strengthen university-industry collaboration.

As interdisciplinary research in doctoral studies continues to evolve, it is essential for academic institutions to adapt and enhance their support mechanisms, including establishing more interdisciplinary platforms, integrating collaborative methodologies into curricula, and providing targeted funding, all while fostering a culture of collaboration (Lyall et al., 2013; Rana et al., 2025; Sun et al., 2021; Vienni-Baptista et al., 2023). We have an efficient support system, including support from faculty and staff, dedicated classrooms and interaction spaces, diverse course content and activity opportunities, as well as grants. Maintaining continuous, ongoing support remains both a crucial component and a significant challenge to this system.

Overall, our case study suggests that a well-structured cross-disciplinary education can effectively prepare doctoral graduates to meet complex societal challenges, thrive in diverse career paths, and contribute meaningfully to both academic and non-academic sectors.

### **Declaration of Generative AI and AI-Assisted Technologies in the Writing Process**

During the preparation of this manuscript, the authors used ChatGPT solely for proofreading and refining language, including correcting grammar, spelling, and rephrasing for clarity and accuracy. Apart from Grammarly, no other AI or AI-assisted tools were used to generate content. All ideas, study design, procedures, findings, analyses, and discussions are original and derived from the careful and systematic conduct of the research.

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