Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46624

Interdisciplinary Engineering Students Training: A Practice of Engineering Minor Degree in China

Dr. Wu Jiayi, Zhejiang University

Jiayi Wu is a Ph.D student in the School of public affairs, Zhejiang University. Her research interests include Engineering Education, Interdisciplinary Research and Innovation Management.

Zhenyu Wu, Zhejiang University
Prof. Tuoyu Li, Zhejiang University

Tuoyu Li is a associate professor of the Institute of China's Science, Technology and Education Policy, Zhejiang University. His research interests include Engineering Education, Science Technology and Education Policy.

Interdisciplinary Engineering Student Development: Practices of Engineering Minor Degree in China

1 Introduction

The rapid evolution of global technological and industrial revolutions has significantly reshaped knowledge production methods and research paradigms. The demands of modern engineering have grown increasingly dynamic, integrative, and uncertain. Engineering practices have expanded beyond traditional technical domains to address challenges related to life, health, and environmental sustainability (Kong, 2009). As a result, engineering problems have transformed from isolated technical issues into multifaceted systems that integrate technical and non-technical dimensions, including economic, societal, environmental, and humanistic considerations. These challenges are marked by their frontier nature, systemic complexity, and interdisciplinary integration. Recognizing these trends, the International Engineering Alliance redefined complex engineering problems in 2021, highlighting their interdisciplinary, creative, and systemic characteristics.

Modern engineers face challenges that surpass traditional expectations, necessitating the ability to access, evaluate, and synthesize knowledge from diverse domains outside their primary expertise (Abell, 2007). To address these challenges and meet the growing need for socially conscious engineers, interdisciplinary engineering education has emerged as a pivotal focus in the field (Roy and Roy, 2021). This approach aims to equip students with the ability to integrate theories, concepts, and methods from multiple disciplines (Lattuca et al., 2004), fostering the development of new knowledge, insights, and problem-solving capabilities (Holley, 2017).

Currently, interdisciplinary engineering education research lacks a universally accepted theoretical framework and cohesive academic structure. Existing studies often focus on various aspects, including the motivations and goals of interdisciplinary education, such as solving complex real-world problems (Lansu et al., 2013), fostering entrepreneurial competencies (Klapper and Tegtmeier, 2010), and promoting social values like sustainability (Apul and Philpott, 2011) . Additionally, scholars have explored ways to improve disciplinary integration. Educational approaches in this domain frequently adopt Problem-Based Learning (PBL) and Project-Based Learning (PjBL). PBL engages students with carefully designed real-world problems, encouraging them to investigate and analyze these issues (Barrows et al., 1980). Similarly, PjBL presents students with open-ended and complex real-world challenges, fostering innovation and collaboration (Brundiers et al., 2010). Other areas of interest include designing interdisciplinary curricula, implementing practice-based learning projects, and developing methods to evaluate interdisciplinary outcomes.Interdisciplinary engineering education aims to cultivate key competencies, including technical expertise within specific disciplines (Ming et al., 2024), cross-disciplinary collaboration skills, systems thinking, and T-shaped abilities (Brown, 2015). Despite its growing recognition as a critical bridge between diverse engineering fields, discussions on its theoretical foundations, practical conflicts, and broader value remain insufficient. Addressing these gaps could further enhance the effectiveness of interdisciplinary engineering education in tackling real-world challenges.

In the practice of interdisciplinary engineering education, universities worldwide have implemented innovative approaches tailored to real-world challenges. Since the early 2000s, Aalborg University has pioneered large-scale project-based education across disciplines, curricula, and semesters using a PBL framework. This initiative primarily addresses the United Nations' 17 Sustainable Development Goals, enabling students to identify, analyze, and resolve problems through authentic, problem-based projects. Collaborative efforts span campuses, universities, and national borders, fostering solutions to global challenges. In 2005, Princeton University launched the Keller Center for Innovation in Engineering Education, bringing together students from engineering, humanities, arts, social sciences, and natural sciences. Through courses on entrepreneurship, innovation, design, and introductory engineering, this interdisciplinary platform seeks to maximize students' creative potential. University College London initiated the "Integrated Engineering Programme" in 2014, structured around three pillars: flexible and practical management methods, a universal curriculum framework, and a tangible platform for engineering education reform (2018). This program has established new collaboration models among educators, professional organizations, and industry stakeholders. Similarly, universities such as the University of Toronto, MIT, and McMaster University have undertaken distinct and impactful experiments in interdisciplinary engineering education.The shift toward collaborative interdisciplinary engineering education is now an established trend. However, current practices often remain confined within disciplinary boundaries, focusing primarily on interdisciplinary efforts within a single discipline. Integration of external disciplines is typically limited to short-term curriculum design and reform, offering only temporary training in interdisciplinary knowledge, skills, and literacy. These limitations significantly hinder the effectiveness of learning outcomes. Therefore, exploring methods to transcend disciplinary constraints and foster long-term, diverse interdisciplinary engineering education remains a pressing challenge.

To address this issue, this study examines the "Advanced Engineering Education Program", an interdisciplinary engineering minor offered by Zhejiang University in China. The program is characterized by four key features: a personalized curriculum system, projects targeting national-level engineering challenges, an interdisciplinary learning environment, and a long-term training framework. Employing an exploratory case study and survey methodology, this research evaluates the program's strengths, challenges, and limitations, thereby contributing to the body of knowledge on engineering minors and advancing interdisciplinary engineering education research.

2 Project Overview

Zhejiang University's "Advanced Engineering Education Program" is an interdisciplinary engineering minor tailored for undergraduate students. Launched in 1994, it represents China's first engineering minor program. At its inception, engineering education primarily emphasized broad natural science principles, with limited focus on clear objectives for engineering practice. To address this gap, the program introduced a customized teaching approach, developing a unique curriculum system, organizational structure, and management framework. The program is dedicated to cultivating high-caliber interdisciplinary talents equipped with professional expertise, innovative capacity, leadership potential, and global perspectives. By integrating practical training, it enhances students' engineering design capabilities, preparing them to contribute to major engineering and technological advancements.

2.1 Program Features 1：Personalized Curriculum System

The Advanced Engineering Education Program emphasizes students' knowledge, design skills, and creativity, following the principles of Problem-Based Learning (PBL). It offers a personalized curriculum system combining required and elective courses (as shown in the figure 1). The courses are primarily concentrated in the second and third years, which are critical for students to quickly accumulate professional knowledge. Core courses, such as "Introduction to Engineering" and "Project Design Practice", span an entire academic year, enabling students to break free from traditional semester-based limitations and disciplinary boundaries. Elective course modules further allow students to tailor their learning to individual interests and goals. Compared to other minor programs, this curriculum requires fewer credits and hours, easing students' workload and granting them more time for hands-on project experience.

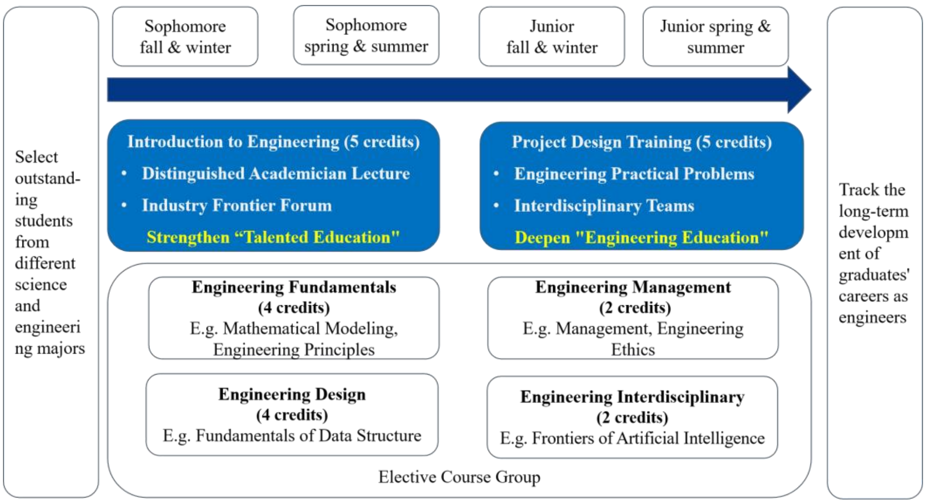

Figure 1 Advanced Engineering Education Class's personalized curriculum system

Administered by Zhejiang University's Honors College, the program awards a minor degree certificate to students who fulfill the credit requirements and maintain satisfactory academic performance, with opportunities to apply for honors certificates. Additionally, a select number of students gain exemption from entrance exams for graduate programs. To maintain high standards, the program employs a rigorous rolling elimination policy, ensuring that only students who consistently meet performance benchmarks remain enrolled.

2.2 Program Features 2：Projects for National Major Engineering Needs

A hallmark of the Advanced Engineering Education Program is its project-centered training approach, which is integral to the curriculum and a core criterion for earning the minor degree. Expert groups identify and discuss major national engineering projects to select a variety of options for students. Chief experts and university-industry mentor teams connect in-class knowledge with research and industrial scenarios, providing students with authentic engineering contexts.

Projects are conducted with students as the main contributors and teachers as facilitators. Tasks are divided into overall and phased objectives, with students independently conducting research, design, fabrication, debugging, and testing to solve real engineering problems (as shown in the figure 2). Based on project progress, needs, and challenges, chief experts organize targeted knowledge-sharing sessions, enabling students to identify, analyze, and solve problems while managing and reflecting on their projects.

Figure 2 Students think and work on projects to solve real engineering problems

For example, in the robotics module, experts propose experimental topics, such as developing two-wheeled robots capable of intelligent navigation, human-robot interaction, and adaptive movement. The project is divided into four stages: research and design, planning, prototype development, and integration. Students must complete tasks including:

- ◆ Conducting technical route research and producing a systems design report;
- ◆ Developing a project plan;

- Engaging in division-of-labor-based development, including literature review, learning technical knowledge, refining technical routes, and hands-on experimentation;
- Iteratively optimizing and integrating the system, culminating in a final demonstration and report.

2.3 Program Features 3：Interdisciplinary Environment

The Advanced Engineering Education Program stands out by fostering an interdisciplinary environment that transcends traditional disciplinary boundaries. The program admits students from diverse engineering majors, and participants are required to attend minor courses and activities during weekends in addition to their primary studies. Typically, first-year students apply at the end of their academic year, and admission is granted through a selective process. The program limits its enrollment to fewer than 50 students per cohort to maintain quality, focusing on applicants' interdisciplinary learning intentions, comprehensive qualities, and potential.

Figure 3 Interdisciplinary teams are engaging in creative activities

Although it is a minor program, each cohort is assigned a class adviser and student committee to facilitate communication and feedback, preventing organizational inefficiencies. Beyond classroom learning, the program strengthens group cohesion through team-building activities, cultural events, and social practices (as shown in the figure 3). Regular inter-year salon events一gatherings that connect students from different academic years, including graduates working in engineering fields—foster cultural continuity and help build a solid interdisciplinary learning team.
The faculty team, comprising experts from diverse engineering fields, collaborates to create a supportive and exploratory learning atmosphere, enabling students to cultivate essential interdisciplinary skills and mindsets.

2.4 Program Features 4：Long-Cycle Training

The Advanced Engineering Education Program employs a long-cycle training system to enhance the integration of scientific knowledge, industrial practices, and educational development. Unlike short-term assessments, this approach emphasizes long-term, process-oriented project evaluations. Spanning two years, the program features year-long required courses such as “Introduction to Engineering”, which provide sustained opportunities for students to consolidate interdisciplinary knowledge through continuous learning and practice.

In the first year, the course “Introduction to Engineering” establishes a multidisciplinary learning environment, integrating engineering theories and practices. Delivered through academic lectures by academicians and industry experts, combined with industry-leading forums, the course uses classic engineering cases to help students understand the values, characteristics, and challenges of engineering practices. Students are also introduced to relevant policies on production, design, research, development, environmental protection, and sustainability. Learning formats include lectures, small-group discussions, and site visits to representative enterprises in the engineering field, offering students direct exposure to real-world engineering practices and fostering interdisciplinary awareness.

The second year centers on “Project Design Training”, which applies project-based learning to tackle real-world challenges in areas such as intelligent manufacturing, robotics, and civil engineering. These year-long projects guide students through a structured learning process, transitioning from identifying “what to do” to mastering “how to do it” and finally optimizing “how to do it better.” Together, these two years form a cohesive training continuum, achieving comprehensive project training from planning to implementation, equipping students with the skills and knowledge to navigate complex engineering tasks.

3 Research Design

3.1 Research Methods

In order to assess the effectiveness of the training model and curriculum of the advanced engineering education program, we developed a semi-structured questionnaire and conducted a survey of alumni from 2007 to 2023 using a stratified sampling method. The sampling principles are as follows:

- ◆ Select 25% of students from each cohort who can be contacted (some students did not complete the program; some students could not be reached).

- ◆ Select students from as diverse a range of majors as possible.

The survey questionnaire consists of three components: demographic questions, Likert-scale-based evaluations, and open-ended questions, allowing for both quantitative and qualitative insights.

3.2 Data Collection

A total of 801 alumni graduated between 2007 and 2023. The survey was distributed via email and text message to 200 alumni, with follow-up phone reminders sent a week later to non-respondents. In the end, 99 valid responses were collected (with invalid responses excluded).

At this point, we observed that the annual sample size was not proportional to the total number of registered students. Specifically, we found that the highest response rate occurred in 2018, at 15%. To address this, we reissued the survey to alumni from other years, ensuring that the sample size for each year was roughly proportional to its registration numbers, with a target response rate of approximately 15% per year. As shown in Figure 4, this resulted in the collection of 118 valid responses.

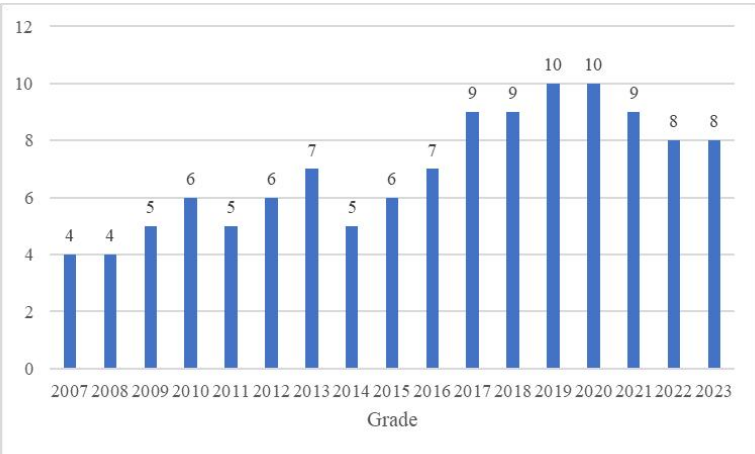

Figure 4 Grade distribution of valid questionnaires

Of the respondents, 95 (81%) were male, and 23 (19%) were female. Participants represented a wide range of engineering disciplines offered by the university, as outlined in Figure 5. For instance, 19 participants (16%) specialized in automation, 16 (14%) in computer science, 13 (11%) in electrical engineering, and 12 (10%) in mechanical engineering. Additional fields included optical engineering, electronic information engineering, information engineering, civil engineering, mathematics, engineering mechanics, biomedical engineering, and chemical engineering. This disciplinary diversity highlights the program's broad appeal and ensures the representativeness of the survey results.

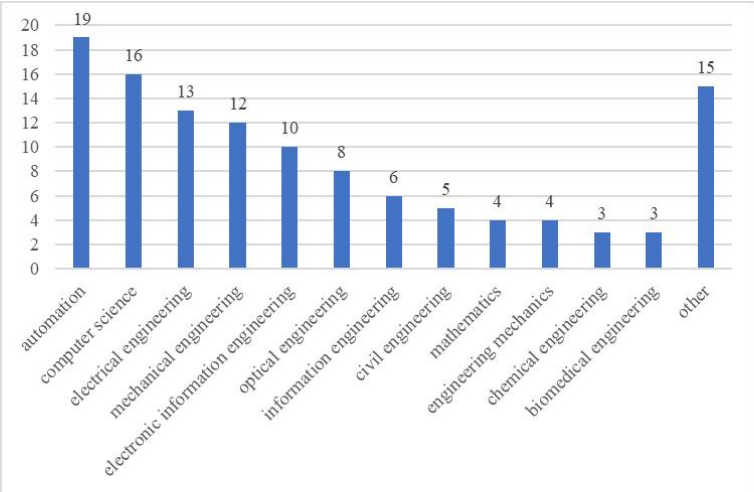

Figure 5 Major distribution of valid questionnaires

3.3 Research Results

3.3.1 Positive Feedback

(1) Course Feedback

To understand students' satisfaction with each course in the minor program, the survey asked participants to rate their experience on a scale of 1 to 5 (1 = very dissatisfied, 5 = very satisfied). Figure 6 shows the satisfaction ratings for seven courses.

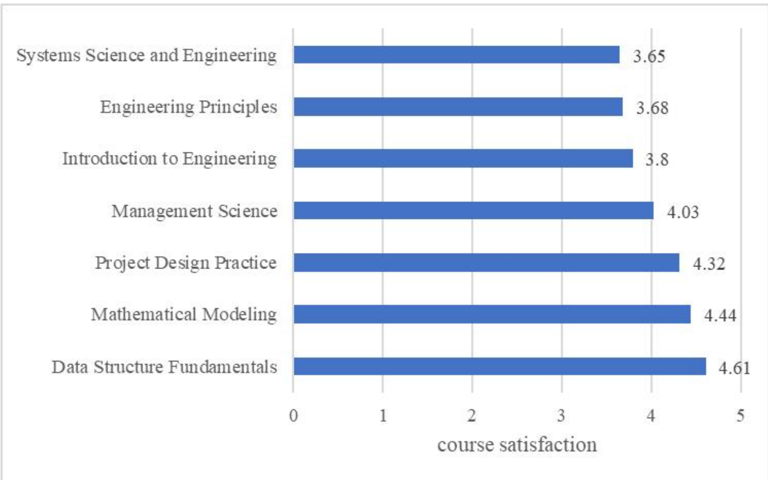

Figure 6 Course satisfaction feedback

The results indicate a high overall satisfaction with the minor program's curriculum, with students generally recognizing the value of its various teaching components. Courses with strong practical applications, such as "Mathematical Modeling" and "Project Design Practice", received the highest ratings of 4.44 and 4.32, respectively. These courses were well-received because they enabled students to apply knowledge to real-world problems, clearly demonstrating the value of their learning.

In contrast, courses like "Engineering Principles" and "Systems Science and Engineering", which focused purely on theoretical content without practical case studies, received lower evaluations. For example, "Data Structure Fundamentals" achieved a relatively high score, with open-ended responses highlighting students' appreciation of its relevance to AI and machine learning. Students noted the importance of mastering foundational programming skills in the context of rapidly advancing AIGC technologies.

Courses such as "Project Design Practice" and "Management Science", which involved project-based learning and close interactions with instructors, also garnered positive feedback. Students valued the collaborative, hands-on nature of these courses, which contributed to their higher satisfaction levels.

(2) Interdisciplinary Learning Experience

Students were asked to evaluate five key features of the program: the minor format, personalized curriculum, projects addressing national engineering needs, interdisciplinary teams, and long-cycle training. Figure 7 summarizes their ratings on a scale of 1 (not helpful at all) to 5 (very helpful).

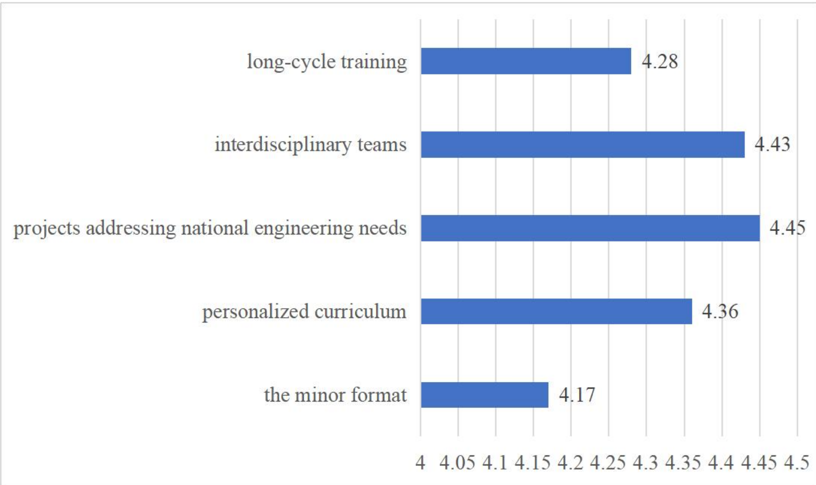

Figure 7 Evaluation of five key features of the program

The results demonstrate that these features significantly enhanced students' interdisciplinary learning outcomes. Projects addressing national engineering needs received the highest ratings, as their integration of diverse tasks encouraged students to break through disciplinary boundaries and apply knowledge across fields.

Similarly, the interdisciplinary team structure was highly rated for promoting collaboration and cross-disciplinary skill development. Other features, such as the personalized curriculum and long-cycle training, also contributed to students' ability to gradually assimilate interdisciplinary knowledge and skills. Collectively, these elements played a pivotal role in fostering interdisciplinary competencies.

(3) Program Outcomes

The survey also collected information on alumni employment and further education. Over 60% of respondents were pursuing advanced degrees (master's, doctoral, or other). As shown in the figure 8, among employed alumni, 51% held positions as engineers or technical experts, 20% were engaged in research roles, and 10% worked in management positions. A smaller number of alumni were entrepreneurs or held government positions.

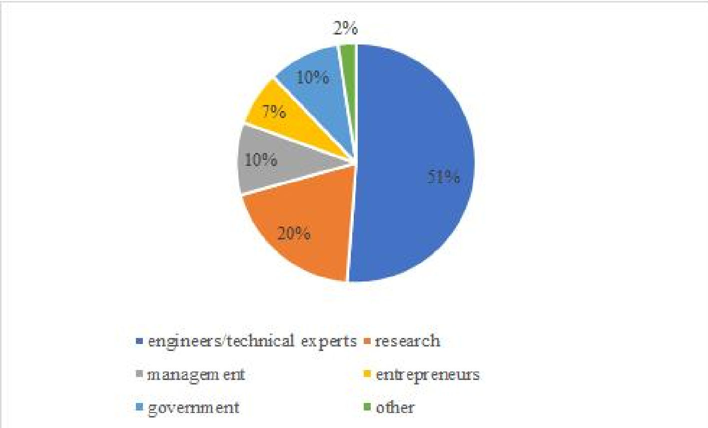

Figure 8 Employment status of alumni

Remarkably, nearly 100% of program graduates continued their studies, with many enrolling in prestigious universities worldwide for doctoral research. Among employed alumni, over one-third had established themselves as leading engineers or technical specialists, underscoring the program's success in nurturing outstanding talent.

3.3.2 Negative Feedback

(1) Weak Industry Relevance of Courses

In addition to evaluating course satisfaction, the survey assessed the industry relevance of each course, asking students to rate how well the curriculum supports their professional development. This analysis aimed to bridge the gap between talent supply and industry demand by determining whether the program equips students with the skills needed for real-world engineering challenges.

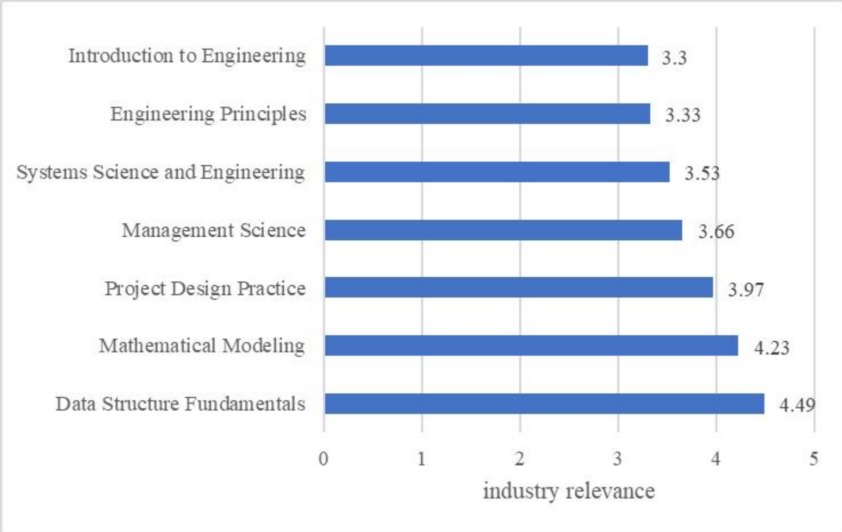

Figure 9 Industry relevance feedback

Figure 9 shows the industry relevance ratings for seven courses. The results revealed that the industry relevance ratings for all seven courses were consistently lower than their satisfaction scores. For instance, "Data Structure Fundamentals" achieved a notable industry relevance score of 4.49. This aligns with the increasing demand for software development and algorithm optimization in the context of rapid digital transformation. Foundational knowledge in data structures is essential for programming roles in high-demand fields like internet technology, fintech, and smart hardware.

However, courses such as "Introduction to Engineering" and "Engineering Principles" received comparatively lower ratings for industry relevance. Their focus on foundational theory, without sufficient integration of practical case studies or real-world applications, may have made it difficult for students to perceive their practical utility.

Interviews with students highlighted potential solutions, such as incorporating emerging topics like artificial intelligence and machine learning into the curriculum. Students also suggested adding content that enhances technical awareness, improves understanding of industry-specific practices, and strengthens hardware design skills, such as electronic circuit design.

(2) Insufficient Engineering Practice Content

The survey also evaluated students' perspectives on the balance between theoretical and practical learning components. Participants were asked to compare the actual ratio of theory to practice in their learning experiences with their ideal ratio based on career development needs. As shown in figure 10, on average, students reported the current ratio as 55:45, whereas their ideal ratio was 42:58.

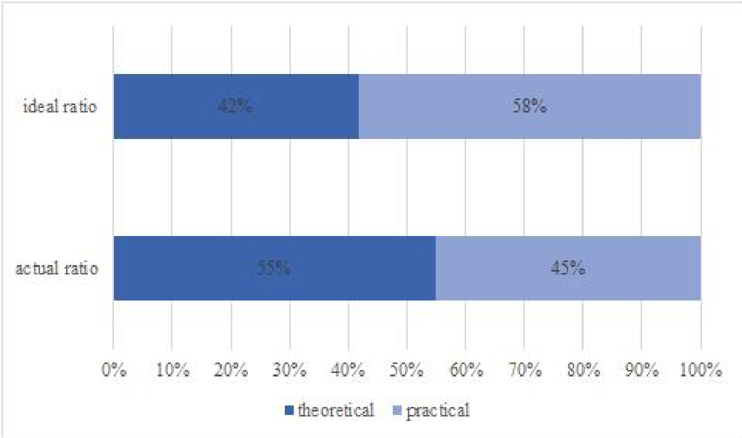

Figure 10 Perspectives on the balance between theoretical and practical learning components

This feedback indicates that the curriculum places excessive emphasis on theoretical content, underscoring the need to increase opportunities for practical engagement. Providing students with more exposure to real-world engineering projects would better prepare them for long-term success in engineering careers.

4 Discussion

4.1 Balancing Interdisciplinary and Engineering Characteristics

As shown in figure 11, this study identified two critical issues in interdisciplinary course design: (i) the industry relevance of courses was generally rated lower than their satisfaction levels, highlighting a misalignment with practical needs; (ii) courses incorporating hands-on project components, such as "Data Structure Fundamentals", achieved higher ratings in both satisfaction and industry relevance. Conversely, purely theoretical courses, like "Engineering Principles", were less favorably received.

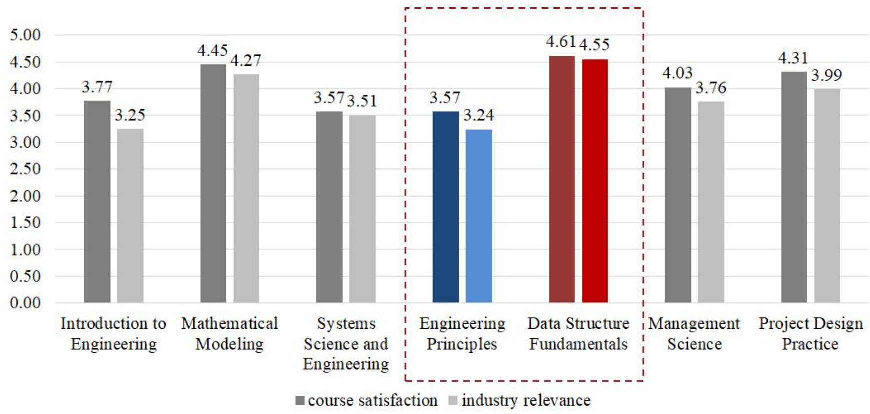

Figure 11 Interdisciplinary and Engineering issues in interdisciplinary course design

This challenge underscores the importance of integrating interdisciplinary and industry-relevant elements into course design. As Entwistle (Entwistle, 2017) noted, academic disciplines inherently follow distinct logical structures, which can lead instructors to revert to discipline-specific methods in interdisciplinary teaching. Without deliberate integration, interdisciplinary courses risk becoming fragmented collections of disciplinary content (Foley, 2016), lacking the cohesive analysis and interaction required for true interdisciplinarity (Huutoniemi et al., 2010) .To address this, interdisciplinary courses should be designed around complex engineering problems derived from real-world scenarios. Faculty and students can collaboratively explore these problems, applying diverse disciplinary knowledge to develop innovative solutions. This approach fosters students' ability to integrate interdisciplinary concepts while enhancing their engineering problem-solving skills.

4.2 Impact of Engineering Projects on Interdisciplinary Competencies

The findings highlight the essential role of engineering projects in cultivating interdisciplinary knowledge and skills. By embedding national-level engineering initiatives into the curriculum, the program exposes students to complex, integrated challenges closely tied to strategic priorities, instilling a sense of responsibility and purpose.

Additionally, the project-based learning framework engages students in a wide range of activities, including research, design, prototyping, debugging, and testing. This hands-on approach promotes critical thinking, systematic problem-solving, and a deeper understanding of engineering processes (Quelhas et al., 2019). However, introducing lower-year students to the complexity and significance of engineering projects remains a challenge. Addressing this issue with targeted pedagogical strategies could further enhance the program's effectiveness in fostering interdisciplinary competencies.

4.3 Institutional Innovation of the Minor Degree Program

The minor degree program represents a groundbreaking institutional innovation in engineering education, breaking down disciplinary barriers to promote interdisciplinarity. Traditional academic structures often constrain interdisciplinary initiatives, as course designs and research typically remain siloed within individual disciplines.

The minor degree format offers students flexible pathways to explore interdisciplinary interests and pursue customized educational goals. It also fosters an inclusive, collaborative environment where students and faculty from diverse backgrounds engage in meaningful academic dialogue. This framework encourages the integration of specialized knowledge into broader interdisciplinary challenges, providing a scalable model for future engineering education reforms.

Future developments could explore additional applications of the minor degree format, such as integrating humanities minors into engineering education to further broaden students' perspectives.

5 Conclusion

This study explored the "Advanced Engineering Education Program", an interdisciplinary engineering minor at Zhejiang University, addressing the critical challenge of cultivating engineering students' interdisciplinary knowledge, skills, and competencies in a systematic and comprehensive manner over an extended period. Through this case study, the research contributes to the practical application of interdisciplinary engineering minors while offering valuable theoretical and practical insights into interdisciplinary engineering education.

Nonetheless, the study has certain limitations. Firstly, the survey targeted cohorts from 2007 to 2023, despite the program's 30-year history. Including alumni from earlier cohorts in future research could yield additional empirical insights and enrich the analysis. Secondly, the discussion of program challenges remains limited. Interdisciplinary engineering education presents complex difficulties for administrators, educators, and students, including curriculum design, resource allocation, and balancing disciplinary depth with interdisciplinary breadth. Future research should focus on these challenges to develop more effective strategies for advancing interdisciplinary engineering education.

Acknowledgments

This study was supported by National Natural Science Foundation of China: The Basic Organizational institution for Total Innovation（72341003）and Chinese Academy of Engineering Strategic Research Consultancy Project（2024-JZ-18）. Additionally, the authors thank the professors and students who partook in interviews and questionnaires for their time and insights.

References

（1）UCL Engineering, 2018 , *Integrated Engineering Programme rated world leading in new MIT report*.https://www.ucl.ac.uk/teaching-learning/news/2018/apr/integrated-engineering-programme-rated-world-leading-new-mit-report.

（2）Abell, 2007, *Handbook of Research On Science Education.* Edition: Lawrence Erlbaum Associates.

（3）Apul, D. S. and Philpott, S. M., 2011, "Use of Outdoor Living Spaces and Fink'S Taxonomy of Significant Learning in Sustainability Engineering Education", *Journal of Professional Issues in Engineering Education and Practice*, 137(2), pp. 69~77.

（4）Barrows, H. S., Tamblyn, R. M. and Others, 1980, *Problem-Based Learning: An Approach to Medical Education*.

（5）Brown, T., 2015, "Strategy by Design - Fast Company".

（6）Brundiers, K., Wiek, A. and Redman, C. L., 2010, "Real-World Learning Opportunities in Sustainability: From Classroom Into the Real World", *International Journal of Sustainability in Higher Education*, 11(4), pp. 308~324.

（7）Entwistle, N., 2017, *Teaching for Understanding at University: Deep Approaches and Distinctive Ways of Thinking*.

（8）Foley, G., 2016, "Reflections On Interdisciplinarity and Teaching Chemical Engineering On an Interdisciplinary Degree Programme in Biotechnology", *Education for Chemical Engineers*, 14, pp. 35~42.

（9）Holley, K. A., 2017, "Interdisciplinary Curriculum and Learning in Higher Education".

（10）Huutoniemi, K., Klein, J. T., Bruun, H. and Hukkinen, J., 2010, "Analyzing Interdisciplinarity: Typology and Indicators", *Research Policy*, 39(1), pp. 79~88.

（11）Klapper, R. and Tegtmeier, S., 2010, "Innovating Entrepreneurial Pedagogy: Examples From France and Germany", *Journal of Small Business and Enterprise Development*, 17(4), pp. 552~568.

（12）Kong, H., 2009, "Engineering Chain:New Challenges to Engineering Education", *Research in Higher Research in Higher Education of Engineering*(02), pp. 23~26.

（13）Lansu, A., Boon, J., Sloep, P. B. and van Dam-Mieras, R., 2013, "Changing Professional Demands in Sustainable Regional Development: A Curriculum Design Process to Meet Transboundary Competence", *Journal of Cleaner Production*, 49, pp. 123~133.

（14）Lattuca, L. R., Voigt, L. J. and Fath, K. Q., 2004, "Does Interdisciplinarity Promote Learning? Theoretical Support and Researchable Questions", *Review of Higher Education*, 28(1), pp. 23~48.

（15）Ming, X., van der Veen, J. and MacLeod, M., 2024, "Competencies in Interdisciplinary Engineering Education: Constructing Perspectives On Interdisciplinarity in a Q-Sort Study", *European Journal of Engineering Education*, pp. 1~22.

（16）Quelhas, O. L. G. C., Lima, G. B. A., Ludolf, N. V., Meiri N O, M. J., Abreu, C., Anholon, R., Vieira Neto, J. and Rodrigues, L. S. G., 2019, "Engineering Education and the Development of Competencies for Sustainability", *International Journal of Sustainability in Higher Education*, 20(4), pp. 614~629.

（17）Roy, M. and Roy, A., 2021, "The Rise of Interdisciplinarity in Engineering Education in the Era of Industry 4.0: Implications for Management Practice", *IEEE Engineering Management Review*, 49(3), pp. 56~70.