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# *Systematic Reform Path for EMI Courses: A Case Study of Principles of Metal Cutting and Machine Tools*

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***Abstract:*** To meet the demand for cultivating internationalized talents in Emerging Engineering Education, this paper addresses five major issues in the English as medium of instruction (EMI) course "Principles of Metal Cutting and Machine Tools": cognitive overload, fragmented content, technological obsolescence, weak practical training, and superficial ideological-political integration. A "four-dimensional driven" reform model is proposed: (1) Cognitive Load Reduction Mechanism: Constructs a three-tiered framework—"Pre-digested Glossary → Dynamic Visualization Resources → Modular Teaching Aids"; (2) Knowledge Topology Restructuring: Establishes a 3D mapping of "Function → Structure → Implementation," integrates universal tool design principles, and embeds intelligent manufacturing modules; (3) Deep Ideological-Political Integration: Designs a three-stage permeation model—"Technical Ethics → Traditional Wisdom → Engineering Standards"; (4) Virtual-Real Collaborative Practice: Develops an ability chain of "Basic Experiments → Comprehensive Training → Industrial Projects." This model provides a standardized reform framework for high-practicality EMI engineering courses, fostering globally competitive emerging engineering talents.

## 1. Introduction

China's higher education strategy in the new era aims to build world-class universities with Chinese characteristics. *The China's Medium- and Long-Term Education Reform and Development Plan (2010–2020)* explicitly states that higher education must "cultivate a large number of international talents with global vision, familiarity with international rules, and the ability to engage in international affairs and competition" [1]. The primary mission of world-class universities is to cultivate high-level international innovative talents. Since 2016, the Ministry of Education has comprehensively promoted "Emerging Engineering Education" to develop interdisciplinary engineering talents with cross-cultural communication skills and global competitiveness. EMI professional courses are a critical pathway for talent cultivation under this initiative.

According to the Guidelines for Ideological and Political Education in Higher Education

Curricula [2] and the College English Teaching Guide (2020) [3], English courses must integrate value guidance and educational functions, blending value cultivation, knowledge acquisition, and skill development. Specifically, English for Specific Purposes (e.g., technical English) should address language barriers in specialized learning. This policy shifts EMI from traditional language training to professional competence development, making it a core measure for internationalizing engineering education.

The core goal of Emerging Engineering Education is to respond to the new technological revolution and industrial transformation by nurturing talents adaptable to emerging industries. Compared to traditional engineering, Emerging Engineering emphasizes interdisciplinarity, innovation, and practicality, particularly focusing on integrating emerging technologies (e.g., AI, IT)with conventional engineering. In this context, EMI courses represent not only a linguistic shift but also an educational paradigm reform. They enable students to directly access cutting-edge knowledge and engage in global academic discourse, enhancing China's influence in engineering education.

The fundamental distinction between Emerging and traditional engineering lies in its dynamic response to industrial changes. With rapid advances in cloud computing, big data, AI, and quantum technology, the competence framework for engineers must evolve from single technical skills to "Technical + Communicative + Innovative" capabilities. Practices from the University of Wisconsin-Madison's "Engineering Sustainability" course demonstrate that modern engineers require non-technical skills—policy analysis, cross-cultural negotiation, and ethical decision-making—to address real-world challenges like clean energy adoption [4]. EMI plays a dual role in this competence restructuring: as a medium for acquiring specialized knowledge (e.g., accessing international journals/projects) and as a platform for cross-cultural skill development (e.g., debates, case studies, teamwork) [5]. For example, role-playing debates ("technical expert" vs. "policy expert") in sustainability courses prompted profound attitude shifts ("180-degree changes") among students [4].

"Principles of Metal Cutting and Machine Tools" is a foundational course for students in Mechanical Design, Manufacturing, and Automation. It applies prior knowledge, underpins advanced manufacturing courses, and constitutes an independent, evolving discipline essential for careers in mechanical design, manufacturing, R&D, and innovation. EMI differs from traditional teaching by:

Enhancing students' professional vocabulary, English literacy, and oral proficiency for efficient utilization of English literature;

Aligning domestic/global disciplinary developments to cultivate an Emerging Engineering mindset and global research capabilities.

## 2. Problems in the Original Curriculum

Teaching practice has revealed the following significant problems in the English-taught Metal Cutting course for both international and domestic students.

### 2.1 Cognitive Overload

The primary challenge is cognitive overload. Engineering courses involve abstract concepts and rigorous logic; using English as the medium adds extra cognitive burden. EMI engineering courses have significantly higher terminology density than humanities/social sciences [6]. Data from Chongqing University's Fluid Mechanics course [7] show that: 85% of students cite insufficient vocabulary as a major barrier; 80% struggle with English listening/speaking; 55% of sophomores can only communicate basically; 40% face significant speaking difficulties. Students must simultaneously process "English decoding → native-language comprehension → concept formation," causing working memory overload and reducing knowledge absorption efficiency. A case study from Beijing University of Science and Technology's "Solid-Liquid Separation" EMI course reveals similar issues: despite passing CET-4/6, mineral processing students rely on rote learning and lack English-thinking patterns [8]. Initial exposure to specialized vocabulary triggers frustration. Cognitive psychology indicates this dual load delays spatial imagination activation, hindering comprehension of concepts like machine tool transmission chains.

## 2.2 Content and Resource Deficiencies

Content and resources suffer from "technological generation gaps" and "cultural incompatibility":(1) Textbook "Localization Failure": Most universities adopt foreign textbooks. While linguistically rigorous and content-rich, they differ from Chinese materials in notation, formulas, and problem-solving approaches. Crucially, they lack Chinese industrial cases, misaligning with local practices. China's Mechanical Engineering Technology Roadmap 2023 notes that CNC technology coverage in foreign textbooks is only 38.2%, far below China's actual industry adoption (89.5%) [9]. (2) Content Obsolescence: EMI content lags behind rapid technological advances. Jiangxi University of Science and Technology found that courses like Engineering Cost omit BIM and smart construction, while overemphasizing outdated manual calculation skills [9]. Comparative analysis of domestic vs. foreign EMI engineering materials is shown in Table 1.

Table 1: Comparative Analysis of Domestic vs. Foreign EMI Engineering Materials

| Dimension | Foreign Textbooks | Domestic Materials |
|---|---|---|
| Technical Novelty | Novel, covers cutting-edge technologies | Slow updates, lags behind development |
| Cultural Fit | Lacks Chinese cases, cultural barriers | Rich local cases, high cultural relevance |
| Language Suitability | For native speakers, high difficulty | Simplified for English as foreign language (EFL) learners |
| Practical Focus | Theory-heavy, insufficient case studies | Practice-oriented, inconsistent case quality |
| Update Cycle | Updated every 3–5 years | Infrequent updates, long cycles |

## 2.3 Ineffective Pedagogy & Single Assessment

Current EMI classes exhibit one-way instruction with minimal interaction. Due to language anxiety, student response rates are only 17.3%, creating a "spiral of silence" [8]. Passive learning limits higher-order thinking (analysis/evaluation/creation) to $<15\%$, below Bloom's Taxonomy's recommended 40% [10]. Practical components face "triple disconnections": (1) From theory: Lab manuals only list steps, preventing conceptual understanding; (2) From engineering: Cases lack real-world scenarios, solving "pseudo-problems"; (3) From innovation: Fixed parameters and restricted trial-and-error suppress critical thinking.

Assessments over-rely on standardized exams, neglecting process evaluation. Fluid Mechanics courses reveal unclear/logically flawed assignments due to English-writing limitations, while inconsistent grading hinders objective evaluation [8]. Jiangxi University's reform advocates a "diversified dynamic assessment matrix" incorporating lab reports, project proposals, and cross-cultural presentations [9].

### 2.4 Faculty & Cross-Cultural Ideological-Political Challenges

EMI instructors face dual challenges: balancing language proficiency and engineering experience. Most hold PhDs but lack industrial exposure ("campus-to-campus" career paths). When teaching emerging technologies (e.g., new processes/materials), they often "teach by the book" without practical case integration. Additionally, they lack cross-cultural sensitivity toward international students. Ideological-political education encounters cross-cultural value transmission barriers: South Asian students may misinterpret "craftsmanship spirit" as "repetitive labor" (uncertainty avoidance index gap: 43); Western students struggle with collectivist "dedication" due to individualist backgrounds (individualism index ratio: 91 vs. 28) [10]. Moreover, ideological elements are often superficially "tagged" (e.g., abruptly inserting patriotism during machine tool structure lectures), lacking organic integration with scientific principles.

## 3. Curriculum Reform Measures

"Principles of Metal Cutting and Machine Tools" is foundational for machining theory/equipment. EMI reforms aim to cultivate comprehensive abilities and global perspectives for bilingual elite talent development. Key measures are as follows.

### 3.1 Tiered Cognitive Load Reduction

A three-tier "Pre-digestion → Visualization → Materialization" model addresses linguistic/spatial barriers:

Tier 1: Language Pre-digestion: Develop a structured glossary (layered: basic terms → process descriptions → fault diagnosis).

Tier 2: Dynamic Visualization: Create interactive 3D animations to concretize abstract concepts. Example: Rotate/section views to demonstrate orthogonal/normal plane conversions; animate gear meshing dynamics with power-flow markers.

Tier 3: Materialized Operation: Design modular teaching aids (e.g., lathe tool angle measurement kits with magnetic protractors; machine tool transmission chain magnetic puzzle boards) to enhance muscle memory via tactile feedback.

### 3.2 Cross-Module Knowledge Restructuring

To counter fragmentation and obsolescence: (1) Modular Knowledge Reorganization: Replace traditional "tool-machine" segregation with a "Function → Structure → Implementation" 3D knowledge map. Horizontally integrate lathe/milling/drill tool knowledge into "universal tool design principles"; vertically update content via a "traditional (conventional lathe) → modern (CNC)→ frontier (digital twin-driven optimization)" axis, adding parallel intelligent manufacturing modules. (2) Localized Material Development: Create EMI lecture notes integrating Chinese mineral processing cases to avoid "direct borrowing," balancing international linguistic standards with cultural/engineering relevance.

### 3.3 Three-Stage Ideological-Political Integration

A fusion framework—"Technical Ethics → Traditional Wisdom → Engineering Standards"—addresses superficial integration:

Stage 1: Techno-Ethics: In "Tool Life Prediction," introduce resource-consumption models to debate ethical boundaries of "precision redundancy design," aligning with SDGs.

Stage 2: Scientization of Traditional Wisdom: Map historical techniques to modern science (e.g., deconstruct "raw iron quenching" from Tiangong Kaiwu to bridge material science and cultural heritage).

Stage 3: Personification of Engineering Standards: Link ISO 3002 tool measurement standards to "craftsmanship spirit" (e.g., "0.01° angle error = 10% lifespan reduction → Precision = Responsibility"), fostering professional reverence.

### 3.4 Industry-Academia Collaborative Practice System

Centered on "Engineering Problem-Driven Competency Leap," a three-tiered practice chain is constructed: Basic Experiments → Comprehensive Training → Enterprise Projects. (1) Foundational Tier: Focuses on equipment operation standards (e.g., tool grinding accuracy inspection), using bilingual lab manuals to eliminate terminology barriers. (2) Comprehensive Tier: Introduces real enterprise failure cases (e.g., diagnosing headstock abnormal noise) to train systemic multi-factor analysis capabilities. (3) Innovation Tier: Addresses current industrial pain points (e.g., chatter suppression in aerospace thin-walled part machining), requiring students to deliver full-English solutions evaluated by dual supervisors. Deep Integration via "Complementary Resources + Controllable Risks" framework. (1) Resource Synergy: Enterprises provide dynamically updated problem databases and production line resources. Universities undertake trial production tasks and co-establish a dual-supervisor system (terminology translation + technical guidance). (2) Mechanism Design: Intellectual property protection through NDA agreements. AR remote guidance to mitigate operational risks. Cross-cultural defence sessions (simulated international technical conferences) to enhance EMI engineering communication. Anchored by real problems, real scenarios, real evaluation, this approach forms a cognitive → analytic → innovative competency cycle, delivering a replicable practical education model for EMI engineering courses. It resolves the dual challenges of "practice-industry disconnect" and "innovation cultivation gap" in EMI curricula.

## 4. Conclusions

This paper addresses five challenges in the EMI course "Principles of Metal Cutting and Machine Tools"—cognitive overload (85% vocabulary barriers), fragmented content (<40% CNC coverage in textbooks), technological lag, practical disconnection, and superficial ideological-political integration (cross-cultural misinterpretation of "craftsmanship spirit")—via a "three-dimensional driven" reform model:

Cognitive Load Reduction: "Pre-digested glossary → 3D dynamic visualization → modular teaching aids" to materialize abstract concepts (e.g., tool angles);

Knowledge Restructuring: Extract "universal tool design principles," establish a "traditional turning → CNC → digital twin" axis, and embed intelligent manufacturing;

Ideological-Political Integration: Link Tiangong Kaiwu techniques to materials science and transform ISO 3002 standards into ethical responsibilities;

Practice Enhancement: Drive capability development via real industrial projects (e.g., thin-walled part vibration optimization). This model transcends language training, offering a replicable "Knowledge-Ability-Value" integrated reform paradigm for high-practicality EMI mechanical courses.

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## References

*[1] State Council of China. (2010). *National Medium- and Long-Term Education Reform and Development Plan (2010–2020)*.*

*[2] Ministry of Education of China. (2020). Guideline for Ideological and Political Education in Higher Education Curriculum.*

*[3] National Advisory Committee on College Foreign Language Education. (2020). College English Teaching Guide (2020 ed.). Beijing: Higher Education Press.*

*[4] Chinese Academy of Engineering. (2021). Made in China 2025: Green Paper on Key Area Technology Innovation. Beijing: Science Press.*

*[5] Felder, R.M., & Brent, R. (2016). Teaching and learning STEM: A practical guide. Jossey-Bass.*

*[6] Evans, S., & Morrison, B. (2011). Meeting the challenges of English-medium higher education: The first-year experience in Hong Kong. English for Specific Purposes, 30(3), 198-208.*

*[7] Academic Affairs Office, Chongqing University. (2022). Survey Report on Learning Barriers in EMI Engineering Courses.*

*[8] Kou J., Sun T.C., Sun C.B., & Xu C.Y. (2016). Practice of EMI for engineering undergraduates. China Metallurgical Education (2), 3.*

*[9] Xu, S., Wang, Y., Xiong, B., & Zhou, Y. (2024). Research on the reform of practical teaching in engineering cost under the background of professional certification: a case study of jiangxi university of science and technology. Open Access Library Journal, 11(10), 9.*

*[10] Chen X.J. (2024). Current status and improvement of EMI engineering courses under Emerging Engineering Education. Science Education Journal (5), 14-16.*