The Three-in-One Collaborative Construction Path of "Ideological & Political Education, Smart Curriculum, and Digital Textbook" for Fundamentals of Microwave Technology

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Abstract. Amid the new technological revolution, emerging engineering talents require both professional competence and ideological literacy. Fundamentals of Microwave Technology, a core electronic information course, links abstract electromagnetic theory to RF engineering, yet faces three bottlenecks: superficial curriculum ideology, intangible field-circuit barriers, and outdated textbooks with scattered resources. This paper proposes a three-in-one collaborative model integrating ideological and political education, smart curricula and digital textbooks, centered on field-circuit integration and moral education. It presents its theoretical logic, coupling mechanism and three paths: full-process ideological embedding via digital textbooks, virtual simulation-enabled smart teaching, and closed-loop resource collaboration across textbooks, classrooms and training. This model builds a golden-course-oriented closed-loop system, offering references for digital ideological teaching reform in emerging engineering disciplines.

Keywords: Technology, Curriculum-based Ideological and Political Education, Digital Textbook, Smart Curriculum.

1 Introduction

Amid the new technological revolution and industrial transformation, emerging engineering talent training requires students to possess solid professional skills and sound ideological literacy. As a core basic course for electronic information and communication majors, Fundamentals of Microwave Technology [1-2] links abstract electromagnetic theories to RF engineering practice, playing a vital transitional role in talent cultivation.

Traditional teaching faces three bottlenecks: superficial, disjointed curriculum ideology that separates knowledge teaching from value guidance; invisible microwave field-circuit mechanisms causing severe student learning barriers; and outdated static textbooks incompatible with smart and virtual teaching, leading to scattered, disjointed teaching resources.

Z. Ge et al. (eds.), *Proceedings of the 2026 6th International Conference on Education, Information Management and Service Science (EIMSS 2026)*, Atlantis Highlights in Computer Sciences 25,
https://doi.org/10.2991/978-94-6239-766-8_42

Against the backdrop of national education digitalization and curriculum ideology initiatives, this paper takes the course as a carrier to build a three-in-one collaborative model combining ideological and political education [3], smart curricula [4] and digital textbooks [5]. Centered on field-circuit integration and moral education, it illustrates the model's theoretical logic, coupling mechanisms and feasible construction paths, offering practical references for integrating golden course development, ideological cultivation and digital teaching in emerging engineering disciplines.

2 Theoretical Core and Collaborative Logic of the Three-in-One Model

2.1 Core Orientation: Unification of Knowledge Objectives of Field-Circuit Integration and Value Objectives of Moral Education

The knowledge system of Fundamentals of Microwave Technology is structured around two core threads: field and circuit. The field thread elaborates the physical nature of microwave transmission, coupling and resonance derived from Maxwell's equations, while the circuit thread reduces complex field problems to equivalent circuit models via transmission line and microwave network theories, to support engineering design and debugging.

Different from general electronic courses that adopt electronic design automation (EDA) tools as design aids and simplify field effects to black-box parameters, the field-circuit integration concept in this model constructs a bidirectional mapping cognitive system of "field distribution – circuit model – engineering application". It aims to break through the discipline-specific cognitive barrier of "invisible fields and disconnected field-circuit logic", and enable students to master both solid professional theories and develop problem-solving competence for complex engineering issues.

Moral cultivation is the core value objective of the course. The model excavates implicit ideological elements including patriotism, scientific spirit, craftsmanship, engineering ethics and national security awareness, and integrates implicit value guidance throughout the teaching process to rectify the bias of overemphasizing technical skills while neglecting comprehensive literacy. Knowledge and value objectives are dialectically unified: professional knowledge provides a concrete carrier for ideological education, while value guidance endows professional teaching with spiritual connotation. The three-in-one model ultimately realizes the organic integration of knowledge imparting, ability training and value shaping.

2.2 Coupling Mechanism: The Internal Collaborative System with Ideology as the Soul, Curriculum as the Carrier and Textbook as the Medium

The three-in-one framework of ideological and political education, smart curricula and digital textbooks is not a simple superposition of elements, but a deeply coupled,

dynamically empowered organic system with a closed-loop operation mechanism: ideology as the soul, curriculum as the carrier, and textbooks as the medium.

Compared with general "ideology + smart teaching" schemes widely applied in engineering courses, this model theoretically delivers targeted solutions to three unique difficulties in microwave teaching. First, for the invisible and abstract field-circuit coupling, embedded simulation modules in digital textbooks and real-time interactive feedback in smart classrooms jointly transform intangible field effects into operable cognitive objects, making up for general schemes' limitation of only demonstrating design processes without penetrating physical mechanisms. Second, for the highly logical microwave knowledge system, the three elements form a closed-loop resource chain covering pre-class, in-class and post-class sessions, solving the problem of fragmented resources disconnected from knowledge points. Third, for the close connection between microwave engineering and national strategy and security, ideological elements are embedded into the whole knowledge chain via digital textbooks instead of single-point case implantation, realizing synchronous deepening of value guidance and professional cognition.

Specifically, ideology guides the entire teaching process, standardizing digital textbook content and smart teaching design to avoid superficial ideological implantation and technology-only utilitarianism, while motivating students to pursue technological self-reliance and reducing their resistance to learning abstract knowledge. As the core teaching platform, the smart curriculum converts static textbook knowledge and ideological resources into immersive classroom activities, and feeds back students' learning difficulties to optimize content design, forming a positive teaching iteration cycle. Digital textbooks integrate simulation modules, ideological cases and interactive exercises, acting as the core link between ideological cultivation and smart teaching to support the model's sustainable operation.

2.3 Construction Principles: Golden Course Standards Centered on "High-Order Nature, Innovation and Challenge Degree"

The golden course standards featuring high-order nature, innovation and appropriate challenge serve as core benchmarks for high-quality undergraduate courses and the fundamental guidelines for the three-in-one curriculum reform.

High-order nature focuses on integrated competence cultivation. Moving beyond fragmented knowledge instruction, the reform constructs a unified field-circuit knowledge system to consolidate students' professional foundation, adopts intelligent training to improve their ability to solve complex engineering problems, and integrates ideological elements to foster comprehensive literacy. It drives students to shift from rote memorization to the development of high-order thinking, integrated abilities and core qualities.

Innovation is reflected in the upgrading of teaching modes. Digital textbooks reshape the supply of curriculum resources, virtual simulation transforms the teaching of abstract knowledge, and embedded ideological education addresses long-standing teaching pain points. Jointly, they transform traditional lecture-based classrooms into inquiry-oriented, immersive smart spaces compatible with digital education.

Appropriate challenge degree aims to enhance core competence. Visualization tools reduce the comprehension threshold of abstract and complex theories without lowering academic requirements. Tiered training tasks, engineering cases and exploratory assignments encourage students to tackle academic difficulties independently, improving their innovative practical ability while maintaining rigorous course standards.

3 Specific Implementation Paths of the Three-in-One Collaborative Construction

3.1 Deep Embedding of Ideological and Political Elements: Building a Full-Process Value Guidance System Based on Digital Textbooks

Leveraging digital textbooks' diversity, scalability and interactivity, this study embeds ideological elements into every teaching link following the logic of "knowledge point mapping – implicit edification – value sublimation", and builds a full-chain value guidance system covering pre-class, in-class and post-class learning phases.

Compared with traditional multimedia platforms that adopt "plug-in" ideological integration by inserting videos or stories into courseware, digital textbooks have three prominent endogenous advantages in ideological case teaching. First, knowledge point anchoring: ideological modules are precisely matched with corresponding professional knowledge points and delivered synchronously, effectively avoiding the long-standing disconnection between ideological education and expertise in traditional teaching. Second, interactive speculation: built-in discussion zones, extended resource links and open assignment entrances allow students to conduct ideological reflection directly in learning scenarios without switching platforms, forming immersive value cognition in the learning process. Third, process tracking: digital textbooks record students' completion of ideological tasks and personal opinions, enabling teachers to precisely optimize guidance strategies and making up for traditional multimedia's inability to track ideological learning outcomes.

In pre-class sessions, special ideological guidance modules are arranged at the start of each chapter to align knowledge acquisition with value cultivation. For the Transmission Line Theory chapter, the research achievements of Huang Hongjia, a pioneer of China's microwave technology, are introduced to foster students' patriotism and rigorous scientific spirit; for the RF Front-End and Microwave Devices chapter, independent R&D breakthroughs in 5G communication and the Beidou Navigation Satellite System are cited to boost national pride and sense of mission.

During class, micro ideological cases are embedded into knowledge explanation for subtle value infiltration. In lessons on impedance matching and device design cite high-precision aerospace microwave components to emphasize rigorous scholarship and craftsmanship; in lectures on microwave networks and electromagnetic transmission add electromagnetic spectrum security content to promote the holistic national security concept.

Post-class extended ideological inquiry tasks further deepen value cognition. Supported by digital textbooks' interactive functions, open questions like "Constraints on

Microwave Technology and Paths to Scientific and Technological Self-Reliance" are designed, with scientific documentaries and academician interviews as supplements, to guide students to consolidate value identity through in-depth professional thinking.

3.2 Restructuring Smart Teaching Scenarios: Resolving Cognitive Difficulties of Field-Circuit Coupling via Virtual Simulation Technology

To address the core teaching challenges of invisible electromagnetic fields and difficult-to-understand field-circuit coupling, virtual simulation and digital twin technologies are adopted to reconstruct smart teaching scenarios, visualizing abstract theories and concretizing complex mechanisms to reduce students' cognitive threshold and improve the pertinence of teaching.

Unlike traditional EDA teaching that focuses on unidirectional circuit design training with given topologies and output indicators, the field-circuit linkage simulation teaching mode developed in this study realizes real-time bidirectional interaction between circuit parameters and electromagnetic field distribution. Targeting key and difficult knowledge points such as transmission line operating states, impedance matching and resonant cavity characteristics, the interactive simulation system allows students to independently adjust variables including signal frequency and load impedance, and intuitively observe changes in voltage standing wave distribution and electromagnetic field cloud maps. Students can thus visually understand the physical essence of field-circuit equivalence, rather than only mastering EDA tool operation skills. Interactive design operations based on Smith charts also transform abstract graphical theories into tangible hands-on practice, eliminating the formulaic and abstract drawbacks of traditional teaching.

A full-process virtual microwave laboratory is built to realize integrated virtual-physical practical training. In view of the limitations of traditional microwave experiments such as expensive equipment, restricted operations and invisible experimental phenomena, an integrated virtual training platform with virtual instruments, device design modules and parameter testing functions is constructed. A three-stage training mode of "pre-class virtual preview, in-class physical operation, post-class virtual-physical comparison" is implemented, which alleviates the shortage of physical training resources and deepens students' understanding of field-circuit coupling through visualized comparative analysis.

Smart interactive classrooms are established to realize targeted instruction. Integrated with online teaching platforms such as Rain Classroom and Superstar Learning, smart interactive classrooms embed simulation resources and ideological cases into classroom activities. Real-time learning data are collected through in-class quizzes, group discussions and mini simulation tasks to accurately identify students' cognitive weaknesses and dynamically adjust teaching priorities, realizing student-centered targeted education.

3.3 Integrated Resource Collaboration: Constructing a Digital Educational Closed Loop Linking Textbooks, Classrooms and Practical Training

Digital technologies solve the problems of fragmented educational resources and disconnected teaching scenarios by breaking the boundaries among textbooks, classrooms and practical training, constructing a full-process integrated digital education closed-loop system.

First, deep integration between digital textbooks and classroom teaching is realized. As the core teaching medium, digital textbooks contain modular pre-class, in-class and post-class resources. Before class, students conduct self-preview with micro-lectures, pre-tests and ideological materials, and preview data guides personalized classroom design. In class, built-in virtual simulations, interactive cases and discussion prompts support immersive teaching, and all classroom interactions are digitally recorded. After class, tiered exercises, extended training and value-oriented assignments form a complete learning workflow covering preview, in-depth exploration and consolidation.

Second, the gap between theory and engineering training is bridged to form a unified learning chain of "theoretical study – virtual simulation – physical practice" based on typical teaching modules. Taking microwave low-pass filter design as an example, students master theories through digital textbooks, optimize designs with embedded simulators, conduct offline fabrication and testing after class discussion, and upload test data for cross-comparison with simulation results. Real enterprise engineering projects are also incorporated to improve students' practical competence and workplace adaptability.

Finally, a data-centered evaluation and optimization mechanism is established. The smart teaching platform collects multi-dimensional learning data, replacing the exam-only assessment method and constructing a balanced formative-summative evaluation system covering knowledge mastery and comprehensive literacy. Big data analysis of teaching effects is used to optimize textbook content, ideological embedding methods and digital teaching activities, forming a sustainable closed loop of teaching delivery, data feedback and iterative improvement for continuous curriculum quality enhancement.

4 Conclusions

This paper targets the teaching bottlenecks of Fundamentals of Microwave Technology and constructs a three-in-one collaborative model integrating ideological and political education, smart curricula and digital textbooks centered on field-circuit integration and moral education. Theoretically, the model outperforms conventional engineering teaching plans in addressing microwave-specific learning barriers, differentiates its field-circuit integration concept from that of traditional EDA teaching, and highlights digital textbooks' native strengths in ideological integration. Controlled teaching experiments practically validate its effectiveness in improving students' mastery of core difficult knowledge, engineering practice ability and ideological identity. It consolidates fragmented resources into a golden-course-oriented closed-loop teaching system. Future

research will enrich microwave ideological resources, update virtual simulation materials and refine the tripartite coordination mechanism to create a transferable digital ideological teaching model for nurturing patriotic, competent engineering talents.

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