

Innovation and Practice of Teaching Methods in Digital and Adaptive Learning: Taking Communication Engineering Major as an Example

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Abstract: This paper proposes teaching reforms in communication engineering majors, emphasizing the implementation of digital and adaptive teaching methodologies, integrating emerging technologies, breaking free from the constraints of traditional education, and fostering high-caliber talents. The reform measures encompass fundamental data collection, recognition of individual characteristics, recommendation of adaptive learning resources, process-oriented teaching management, adaptive student guidance and early warning systems, personalized evaluation, and the construction of an integrated service platform. These measures, when combined, form a comprehensive system that is expected to enhance teaching quality and efficiency, and facilitate student development.

Keywords: Digital learning; Adaptive learning; Communication Engineering; Teaching reform; Talent cultivation; Integrated service platform

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1. Introduction

Amidst the new wave of industrial transformation, cutting-edge information technologies such as big data, cloud computing, and artificial intelligence have penetrated deeply into scientific advancements and national production. China is actively promoting major strategies like “Digital China,” “the Belt and Road,” and “Cyber Power.” However, the shortage of highly skilled and practical talents has led to a surge in the demand for professionals in fields like artificial intelligence and communication engineering. According to the forecast in the “Manufacturing Talent Development Plan Guide,” China will face a significant talent gap of 9.5 million individuals in the new-generation information technology industry by 2025. To bridge this gap and enhance China’s technological prowess, the General Office of the Ministry of Education has issued the “Notice on Carrying Out Research and Practice of Emerging Engineering Education.” This initiative aims to transform traditional engineering disciplines into emerging ones, addressing critical “bottleneck” issues and strengthening

China's "hard power."

As a key discipline under the "Emerging Engineering Education" initiative, the communication engineering major requires updates and upgrades to align with the construction and development trends of this new paradigm. Continuously exploring digital and adaptive learning methodologies tailored to the unique teaching realities of the communication engineering major, with the aim of enhancing China's core competitiveness, represents a significant challenge currently faced by the country.

Traditional Chinese educational models suffer from drawbacks such as prioritizing knowledge transmission over skill development and neglecting individual differences. This approach, characterized by a degree of conservatism and closed-mindedness, is detrimental to sustainable student development and the cultivation of innovative talents. Consequently, the absence of digital and adaptive learning methodologies that can adapt to the evolving needs of "Emerging Engineering Education" has emerged as a bottleneck, constraining the effective talent cultivation process.

2. Existing issues

There are a few issues in the teaching of communication engineering majors:

- (1) Traditional educational models struggle to meet the demands for new technologies in communication engineering majors under the emerging engineering context, lacking effective application paths and methods for integrating emerging technologies into education and failing to provide a digital curriculum resource system tailored to students' individual needs.
- (2) Current teaching methods in communication engineering majors are overly conventional, lacking innovation and adaptability, unable to fulfill the requirements for nurturing students' innovation and entrepreneurship capabilities and underutilizing emerging technologies to improve teaching approaches and strategies.
- (3) There is a lack of a mature and scalable model and methodology for digital and adaptive learning in communication engineering education.

3. Teaching reforms in communication engineering majors

Under the "Emerging Engineering Education" framework, the "Internet + Higher Education" talent cultivation model has emerged, breaking the shackles of traditional education and offering personalized and diversified learning modes, presenting significant opportunities for educational development and driving transformational innovation.

Adaptive teaching necessitates teachers' meticulous design of self-study resources and accompanying task lists based on students' individual characteristics, enabling each student to access the most suitable learning resources according to their needs and optimizing learning time and resource utilization. This encompasses a comprehensive understanding of students' personality traits ^[1], personalized learning resource recommendations, process-oriented teaching management, personalized learning behavior and situations, and multi-dimensional personalized learning evaluations ^[2].

By deeply integrating emerging technologies such as cloud computing ^[3], the Internet of Things, virtual simulation, and educational big data, we aim to promote their integrated application in communication engineering education and teaching and achieve innovation and practice in digital and adaptive learning teaching methods. The overall framework is shown in **Figure 1**.

Firstly, we collect students' basic data through multiple channels to provide data support for personalized

teaching. Secondly, based on this data, we gain an in-depth understanding of students' personality traits, clarifying their learning needs and differences in potential abilities.

Building upon this foundation, the collaborative construction of personalized learning resources between schools and enterprises and the utilization of modern information technology and personalized recommendation algorithms can present students with resources tailored to their interests and needs. Concurrently, process-oriented teaching management is implemented, and comprehensive management before, during, and after class is achieved through a personalized comprehensive teaching service platform to ensure the pertinence and effectiveness of teaching.

Moreover, this paper emphasizes personalized student guidance and learning situation warning systems, providing targeted guidance based on real-time analysis of students' learning status and characteristics while anticipating and alerting potential academic crises and risks.

To comprehensively evaluate students' learning effect, this study implemented a multi-dimensional personalized assessment method, integrating international standards and the Ministry of Education's professional norms to assess students' comprehensive abilities from various aspects.

Lastly, by building a personalized comprehensive teaching service platform and a course group practice support plan, technical support and practical guarantees will be provided for the accuracy and efficiency of personalized teaching^[4].

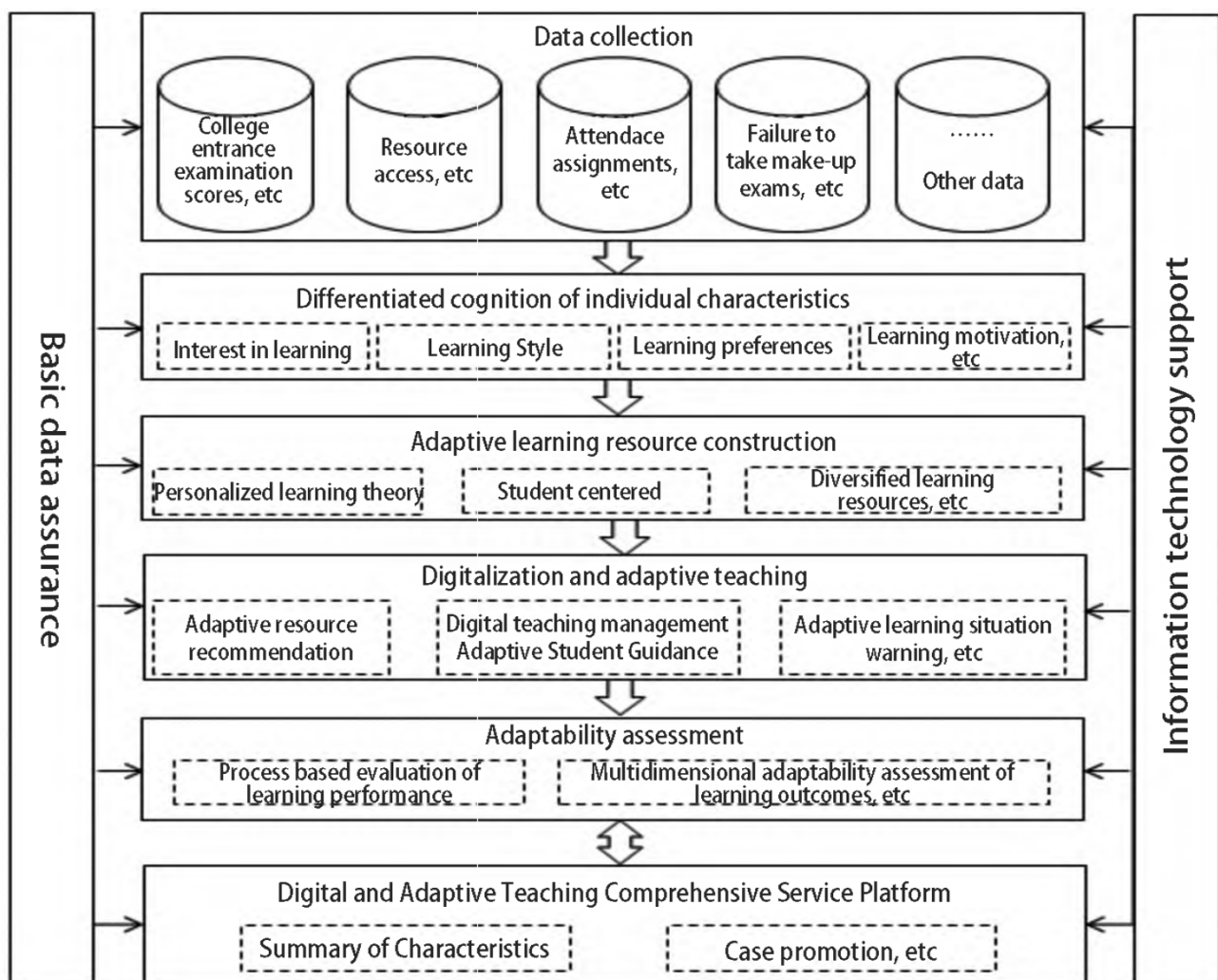


Figure 1. Overall framework for digital and adaptive learning in communication engineering education

4. Specific measures for teaching reform in communication engineering majors

4.1. Fundamental data collection plan

Through the strategic application of desensitization methodologies within the educational management system, we are able to procure foundational data that is intricately linked to the unique learning histories and diverse backgrounds of our students ^[5]. The comprehensive course teaching management system, with its exhaustive capabilities, meticulously compiles a wide array of information including attendance registers, homework submissions, detailed metrics of resource utilization, and extensive behavioral logs that span the entire duration of the communication engineering curriculum. To further deepen our analytical insight and understanding, we supplement this wealth of data with carefully crafted questionnaires, designed to augment and enrich our comprehension of each student's individual learning patterns and preferences. This comprehensive and multi-faceted approach establishes a robust and scholarly foundation, which is essential for the accurate recognition and digitization of students' unique personality traits and learning styles. By doing so, we lay the groundwork for the implementation of adaptive teaching methodologies that are finely tuned and tailored to the specific needs and learning preferences of individual learners, thereby enhancing the overall educational experience and outcomes ^[1].

4.2. Student individual characteristic recognition plan

Adaptive learning is a pedagogical approach that hinges on a comprehensive understanding of the unique characteristics of each student. This method involves leveraging the vast troves of educational big data to employ sophisticated data mining techniques ^[6,7]. These techniques are designed to analyze and interpret the demographic characteristics of students, thereby gaining insights into their cognitive abilities and adaptive learning needs. By delving into this data, educators and developers can uncover the learning potential of individual students, identifying their specific learning motivations, interests, and preferred styles ^[1]. This granular understanding is essential for tailoring educational experiences that are not one-size-fits-all but rather are finely tuned to the individual. The ultimate goal is to establish a solid foundation upon which targeted, adaptive learning services can be built, ensuring that each student receives a personalized education that maximizes their learning outcomes and fosters a deeper engagement with the material.

4.3. Adaptive learning resource construction plan

In partnership with key players from the industry, our objective is to establish a comprehensive digital library of educational resources, specifically designed to align with adaptive learning principles. This extensive collection will encompass a diverse range of materials, meticulously curated to support learners throughout every phase of their educational journey—from foundational content to advanced, knowledge-intensive resources, practical, hands-on activities, and reinforcement tools for mastered concepts.

To bring these resources to life, we will harness an array of state-of-the-art tools and technologies, including screen recording software, digital drawing tablets, dynamic PowerPoint presentations, and informative videos ^[8]. The content will be crafted with precision to be both accessible and captivating, presented in formats that resonate with contemporary learners, such as succinct video tutorials, interactive online texts, and vivid, informative visuals.

Our overarching goal is to ensure that these materials are student-focused, creating an environment where learning is not only efficient but also customized to meet the unique needs and preferences of each learner, thereby optimizing educational outcomes.

4.4. Adaptive learning resource recommendation plan

Leveraging the latest advancements in information technology and employing sophisticated personalized recommendation algorithms ^[9], this comprehensive educational plan meticulously tailors an array of learning resources to align perfectly with the distinctive characteristics and personal interests of each student. The process begins by gathering demographic features, which serve as the foundational data points. Following this initial step, the system refines and zeroes in on the individual's interests through the application of dynamic demand adjustment models. These models are designed to evolve and adapt based on the student's interactions and feedback, ensuring that the educational content remains engaging and relevant.

Once the interests are honed, the plan delves into a thorough analysis of academic data to pinpoint any learning weaknesses or gaps in the student's knowledge. This analytical phase is critical as it provides actionable insights into areas that require additional support or resources. With this detailed understanding of the student's academic standing and personal inclinations, the educational framework then recommends suitable adaptive learning resources. These resources are not one-size-fits-all; instead, they are dynamically adjusted to cater to the specific needs of the learner, ensuring a personalized and effective educational journey.

By integrating cutting-edge technology and a deep understanding of each student's learning profile, this plan aims to create a highly individualized and responsive learning environment. The ultimate goal is to foster an educational experience that is both tailored and adaptive, thereby enhancing the student's engagement, comprehension, and overall academic success.

4.5. Process-oriented teaching management plan

A comprehensive and personalized teaching platform is designed to streamline and enhance the educational experience from the preparatory stages before class, through the interactive processes during class, and extending into the follow-up activities after class. This platform employs a problem-oriented methodology and a task-driven approach, ensuring that each student receives customized pre-assignments that are specifically tailored to their individual learning needs and current skill levels. During class, the platform provides targeted in-class clarifications, addressing the unique questions and challenges that arise in real time, thereby ensuring that all students have a clear understanding of the material being presented. Following class, the platform offers adaptive post-class assistance, which includes supplementary resources and personalized feedback to reinforce the learning that took place in the classroom ^[9,10].

Moreover, this advanced teaching platform continuously records and monitors teaching and learning behaviors as they occur, capturing a wealth of data on student engagement and comprehension. This real-time data collection enables the platform to deliver adaptive guidance, automatically adjusting the learning materials and support to match the evolving needs of each student. Additionally, the platform conducts performance analysis, identifying areas where students may be struggling or excelling, and provides insights that can inform both teaching strategies and individual study plans. By leveraging these features, the platform ensures a highly personalized and responsive learning environment, ultimately fostering a more effective and efficient educational journey for all learners ^[11].

4.6. Adaptive student guidance plan

Through the utilization of a comprehensive digital and adaptive teaching integrated service platform, educators can gain a detailed understanding of each student's learning progress, pinpoint areas where students may be struggling with specific knowledge points, and identify any weak links in their learning process ^[10]. This platform allows for real-time monitoring of whether students have completed their homework assignments, tracks the amount of time they spend on these tasks, and provides immediate assistance if they encounter

any difficulties or confusion. By employing association rule analysis, the platform can delve into students' behavioral patterns and characteristics, swiftly identifying those who require assistance and pinpointing their exact needs. Consequently, this enables teachers to offer timely, targeted, and adaptive guidance to support each student effectively, ensuring that they receive the help they need to overcome challenges and continue to progress in their learning journey.

4.7. Adaptive academic warning plan

Big data analysis technology can be used to monitor the process of adaptive learning ^[8]. By employing sophisticated data mining algorithms, we are able to predict and identify potential academic difficulties and risks that students might face in advance. This proactive approach involves the utilization of data visualization tools and message-pushing technology to deliver real-time alerts and notifications directly to students and educators ^[12]. The aim is to enhance students' comprehension of their learning journey, enabling them to promptly recognize and rectify any deviations in their learning methods and strategies. Consequently, this comprehensive strategy not only aids in the early detection of learning obstacles but also fosters a more effective and efficient adaptive learning experience, thereby significantly improving the overall quality of personalized education.

4.8. Multi-dimensional personalized evaluation plan

In accordance with the guidelines set forth by the Institute of Electrical and Electronics Engineers (IEEE), the Guide to the Software Engineering Body of Knowledge (SWEBOK), the Software Engineering Education Knowledge (SEEK), and the Chinese Ministry of Education's Communication Engineering Standards, this comprehensive educational plan incorporates a multifaceted evaluation system. It seamlessly blends self-assessment, peer review, parental evaluation, teacher assessment, and industry feedback to comprehensively gauge students' academic and personal development. This integrated approach not only measures students' performance in their studies but also delves into their problem-solving capabilities, thought processes, practical competencies, and overall mental and physical well-being. Additionally, it evaluates their interpersonal skills and contributions to society, thereby nurturing a virtuous cycle where continuous evaluation drives and enhances the learning experience. This holistic evaluation strategy aims to create a balanced development environment that encourages students to excel in all aspects of their educational journey, preparing them not only academically but also socially and professionally for the challenges they will face in their future careers.

4.9. Digitalized and adaptive teaching integrated service platform construction plan

Taking into account the aforementioned strategies, the development of a comprehensive service information system platform for personalized teaching tailored to communication engineering majors is achieved through the utilization of cutting-edge information technologies ^[11]. These technologies encompass big data analytics, advanced database management, the dynamic capabilities of Ajax, and the power of visualization and message push notifications. This innovative platform is built upon the robust foundations of HTML5, CSS3, JavaScript, J2EE, and .NET among other relevant technologies. The aim is to foster an environment that supports the sharing of interdisciplinary theoretical knowledge and facilitates collaborative practical exercises, all within the context of mass learning methodologies. Furthermore, this sophisticated system is designed to offer substantial technical support, thereby enhancing the precision and efficiency of adaptive teaching approaches. By doing so, it ensures that educational content is not only tailored to individual student needs but also delivered in a manner that maximizes learning outcomes and optimizes the overall teaching experience.

4.10. Course group practice support plan

The course group for the implementation of individualized teaching in communication engineering majors primarily encompasses Electronic Information Introduction, Data Structures and Algorithms, C Language Programming, Communication Principles, Signals and Systems, and Microcontroller Principles.

In the course of teaching practice, firstly, in the prerequisite courses such as Electronic Information Introduction offered to freshmen, a self-developed system is utilized to collect students' basic information, including age, hometown, and college entrance exam scores, laying a foundation for subsequent personalized learning guidance.

Secondly, in follow-up theoretical courses like Data Structures and Algorithms, based on the understanding of students' interests and competency levels gained from previous courses, a balanced clustering algorithm is employed to divide students into groups, ensuring comparable overall competence within each group. Subsequently, students are guided to independently carry out adaptive research-oriented thematic learning and encouraged to share their learning outcomes with other groups, thereby rapidly expanding their theoretical knowledge base.

Finally, in subsequent practical teaching courses in communication engineering majors, based on the mastery of students' interests, skills, and knowledge, they are led to engage in training programs that cultivate practical skills such as feasibility analysis, requirements analysis, system design, coding implementation, and system maintenance for adaptive practical engineering projects.

This approach effectively deepens students' practical skill structure. Ultimately, it not only ensures the effectiveness of the reform implementation but also provides strong support for fostering students' capabilities as outlined in the talent cultivation program of this major^[10].

5. Conclusion

This paper proposes the main approach for teaching reform in communication engineering majors, which is to implement digital and adaptive teaching, and deeply integrate emerging technologies such as cloud computing, the Internet of Things, virtual simulation, and educational big data to promote their integrated application in education and teaching. This approach aims to break the shackles of traditional education and provide personalized and diversified learning methods, thereby stimulating students' innovative spirit and entrepreneurial ability, and cultivating high-quality talents that meet the needs of the new era.

To achieve this goal, specific reform measures include basic data collection, recognition of students' individual characteristics, construction and recommendation of adaptive learning resources, process-oriented teaching management, adaptive student guidance and academic performance warning, multi-dimensional personalized evaluation, as well as the construction of a comprehensive service platform for digital and adaptive teaching. These measures are interconnected and mutually supportive, jointly forming a complete system for teaching reform in communication engineering majors.

By implementing these reform measures, it is anticipated that we can address many issues existing in current education, enhance teaching quality and efficiency, and promote students' all-round development and innovative abilities. At the same time, this will also provide strong talent support for China's technological progress and industrial development, and facilitate the smooth implementation of major strategies such as "Digital China," "the Belt and Road Initiative," and "Cyber Power."

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Disclosure statement

The authors declare no conflict of interest.

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