Generative AI + Competition-Driven Empowerment for Innovative Practical Teaching of SDN: A Case Study of SDN Curriculum Reform

Xinyu Geng*, Ruxia Wang, Xueri Li
Computer Science Department - Network Engineering Major, Guangdong University of Science and Technology, Dongguan, Guangdong, China
**Corresponding Author*

Abstract: This paper addresses the pain points in traditional Software-Defined Networking (SDN) education—such as the disconnect between theory and practice, high costs associated with setting up experimental environments, and outdated content on new technologies-by proposing a deeply integrated teaching model that combines generative AI with competition-driven learning. The paper analyzes the advantages of AIGC technology in assisting lesson preparation, automatically generating lab scripts, real-time error detection, and building virtual simulation environments. By integrating the "competition-driven teaching" philosophy, it constructs a closed-loop teaching system encompassing "theory-experiment-competition." This model utilizes large AI models to optimize teaching resources and experimental guidance, introduces virtual simulation platforms such as OpenLAB to lower the barrier to experimentation, and leverages competitions like the "Network Technology Challenge" to establish a tiered training mechanism comprising "preliminary-semi-final-final" rounds, effectively addressing the scarcity of SDN experimental resources and the lack of personalized guidance.

Keywords: Generative AI; Event-Driven; Software-Defined Networking (SDN); Curriculum Reform; Practical Teaching

1. Introduction

1.1 Research Background

Against the backdrop of the deep integration of Internet Plus" and "AI Plus," traditional teaching models can no longer meet the demands of cultivating talent in new engineering disciplines. Software-Defined Networking (SDN), as a key direction in the evolution of networking technology, centers on decoupling the hardware and software of network devices. Traditional SDN curricula lag behind in content updates, focusing primarily on TCP/IP fundamentals while covering new technologies such as OpenFlow, automated network operations and maintenance, and zero-trust security only minimally. Furthermore, textbook case studies often depict idealized scenarios that are difficult to implement in practice. Consequently, SDN education faces the challenge of a "disconnect between theory and practice." However, the widespread adoption of generative AI tools like ChatGPT offers a new opportunity to address this challenge. In line with the Ministry of Education's call to "promote teaching through competitions," integrating AIGC technology [1] into SDN course instruction can both enhance teaching quality and cultivate students' innovative practical skills. By shifting from knowledge to competency development, students will not only be proficient in building SDN networks but also able to utilize programming languages and AI tools to achieve network automation and self-healing, thereby gaining the practical skills required to compete in vocational competitions such as the "Network Technology Challenge."

1.2 Significance of the Study

This paper aims to explore how to deeply integrate "generative AI" with "competition-driven" approaches to establish a new, student-centered model for SDN practical instruction. By analyzing the current state of SDN courses in Chinese universities and examining the current applications of AIGC technology in education, this paper proposes a closed-loop teaching system comprising "theory—experiment—competition," with the goal of providing a replicable model for reforming SDN courses and, more broadly, computer networking curricula.

2. Current State of Research

2.1 The Application of Generative AI in Education

The application of generative AI in education has become a hot topic of research. Kohnke et al. demonstrated that ChatGPT significantly improved learners' writing coherence and lexical diversity [2]; Sun Yicheng et al. also discussed the reliability of AI tools [3]; and Xiong Z et al. examined student acceptance of AI in teaching [4]. AIGC can not only assist teachers in lesson preparation and the generation of teaching resources but also support student learning through intelligent assessment. Domestic scholars have pointed out that AIGC technology can empower teaching and learning, particularly in terms of knowledge construction and skill development in higher education. AI technology has already been widely adopted across various disciplines, such as university English and mechanical engineering [5-7].

2.2 Current Status and Challenges of SDN Education

In the context of the new era, the integration of artificial intelligence and engineering practice is of pressing importance [8]. As a key component of the development of new engineering disciplines, SDN courses have traditionally relied primarily on theoretical instruction, lacking a realistic network laboratory environment. The publication of textbooks such as Fundamentals of Software-Defined Networking (SDN) Applications (Micro-Course Edition)* has provided theoretical support for practical instruction. However, there remains a slight deficiency in the experimental component, and lessons can be drawn from the reform processes of other engineering disciplines [9].

2.3 Competition-Driven Teaching Model

"Using competitions to enhance teaching" is a key approach for universities to deepen educational reform. By designing challenging competition problems, educators can effectively stimulate students' interest in learning and enhance their practical skills. For example, Tsinghua University High School has achieved remarkable results in English instruction by integrating the AI+ concept with teaching competitions. In computer science courses, the "using competitions to promote learning" talent development model has explored new pathways for AIGC-enabled teaching through integrated training and the integration of industry, academia, and research.

3. Development of Teaching Models

3.1Theoretical Instruction: AI-Assisted Generation of Teaching Resources

Against the backdrop of digital transformation in education, teachers face challenges in lesson preparation, such as complex content, time-consuming and labor-intensive processes, and a lack of targeted focus. The emergence of large language models like ChatGPT offers an efficient solution to these challenges, helping teachers simplify the lesson preparation process, improve the quality of their lesson plans, and effectively reduce the burden of preparation, thereby allowing them to devote more energy to classroom instruction and student guidance [10].

By leveraging large language models like ChatGPT, teachers can automate the generation of teaching PowerPoint presentations, mind maps, and case study question banks for each chapter, thereby reducing their workload at the core level of lesson preparation materials. In traditional lesson preparation, teachers must spend significant time organizing key points from textbook chapters, designing PowerPoint layouts, drawing mind maps, and selecting or creating case study question banks. This process is not only time-consuming but also prone to issues such as omissions of key points, logical inconsistencies, and a lack of relevance in case studies. In contrast, large language models can quickly extract core knowledge points, key challenges, and knowledge frameworks from the original textbook text and syllabus requirements, automatically generating well-structured and comprehensive teaching PPTs—eliminating the need for teachers to edit each slide individually. These PPTs can automatically embed diagrams, formulas, and code snippets (for subjects like science and computer science) that align with the knowledge points, and can even distribute content across pages according to the teaching pace to avoid information overload or omissions; Additionally, they can generate logically rigorous, well-structured mind maps that connect scattered knowledge points within a chapter, clearly illustrating the relationships between concepts. This helps teachers quickly grasp the teaching framework and facilitates the subsequent presentation of the knowledge system to students; Furthermore, large language models can combine chapter-specific learning objectives, key teaching points, and students' cognitive levels to automatically generate highly targeted question banks. These cover various difficulty levels—including foundational, advanced, and extension questions—with detailed solutions provided for each, saving teachers significant time spent on selecting, adapting, and writing questions and solutions while ensuring the question bank's professionalism and relevance.

Beyond the automatic generation of basic lesson preparation materials, large language models like ChatGPT can also deeply distill textbook content and optimize the design of teaching activities, further enhancing the efficiency and quality of lesson preparation. Textbook content is often verbose, containing extensive introductory and explanatory text. Teachers must spend time distilling core content and organizing instructional logic, whereas large language models can rapidly extract and integrate textbook content, removing redundant information while retaining key knowledge points, key challenges, and critical teaching points. The teaching PowerPoint presentations generated on this basis not only precisely align with textbook requirements but also highlight teaching priorities, preventing teachers from wasting time on content selection.

Addressing the challenge of designing teaching activities—a key hurdle in lesson preparation—large language models can automatically generate diverse, targeted activity plans by integrating chapter-specific knowledge points, student age characteristics, and instructional objectives. These include classroom discussion topics, group collaboration tasks, scenario-based simulations, and inquiry-based experiment designs, thereby overcoming the limitations of traditional lesson planning, such as "restricted thinking and monotonous formats." The generated activity plans are not set in stone; teachers can easily modify, adjust, and optimize them based on their teaching style and the specific circumstances of their class. This eliminates the need to design activities from scratch, significantly reducing preparation time while ensuring activities are more aligned with classroom realities and are both engaging and effective.

For different programming languages (Python, Java, Go), AI automatically generates OpenFlow protocol parsing code to meet the learning needs of students at various proficiency levels, helping them master the subject from multiple perspectives.

To address the challenge of not being able to provide one-on-one Q&A during instruction, a teaching assistant based on large language models can be developed to offer students 24/7 "on-demand" support, resolving various errors encountered during experiments and alleviating the dilemma of teachers being unable to provide individual assistance in the classroom.

3.2 Laboratory Instruction: AI-Powered Lab Assistants

3.2.1 Setting up an ai-driven automated testing environment

In traditional network laboratory instruction, setting up SDN (Software-Defined Networking) experimental environments often faces challenges such as high costs, high barriers to entry, and limited flexibility—not only does it require the purchase of a large number of physical network devices (such as switches, routers, and controllers), but also requires manpower for device debugging, environment deployment, and maintenance. Furthermore, a single physical environment struggles to accommodate the diverse experimental needs across different levels and topics, severely limiting the scope and flexibility of experimental instruction. To address this challenge, AI technology can be leveraged to build a flexible and configurable SDN experimental environment, fundamentally reducing experimental costs and enhancing efficiency. Through virtualization technology and intelligent scheduling algorithms, AI technology pools physical device resources, automatically allocating virtual resources and configuring network parameters based on experimental requirements, eliminating the need for manual deployment of complex hardware connections. Whether for basic network topology testing or complex SDN protocol validation, AI can dynamically adjust environment configurations to achieve "on-demand setup and release upon completion." This approach not only reduces the costs of purchasing and maintaining physical equipment but also prevents resource waste, ensuring that every student has access to an independent experimental environment. It thoroughly resolves the core issues of high costs, low efficiency, and resource constraints inherent in traditional experimental setup.

3.2.2 AI-assisted experiment script generation

Writing experimental scripts is a fundamental component of SDN experiments and one of the main challenges students face. In traditional teaching, students must spend a significant amount of time learning Mininet script syntax and network topology design logic just to complete basic scripting tasks. This not only consumes excessive study time but also often leads to experimental failures due to syntax errors or unreasonable topology designs, which can dampen students' motivation. To simplify this process, AI technology can be leveraged to automate the generation of experimental scripts, allowing students to devote more energy to understanding experimental principles and analyzing experimental results. The AI system deeply analyzes the course syllabus to accurately identify the core requirements of different experimental modules (such as topology, device parameters, and protocol configurations). By combining students' learning progress with the difficulty of the experiment, it automatically generates tailored Mininet experimental scripts. These scripts include complete topology definitions, device configurations, and link parameter settings. Students do not need to master complex scripting techniques; they simply need to click to run the script to quickly set up complex network topologies. This significantly lowers the barrier to entry for experiments, ensures the standardization and accuracy of experimental scripts, reduces experimental failures caused by scripting errors, and improves the smoothness of experimental instruction.

3.2.3 Real-time AI error detection and debugging guidance

During SDN experiments, due to complex network topologies and rigorous protocol logic, students are highly prone to encountering various errors during operations (such as switch connectivity failures, communication anomalies between controllers and switches, flow table configuration errors, and port mapping mistakes). In traditional teaching methods, instructors must review students' lab logs one by one and manually analyze the causes of errors. This process is not only time-consuming and labor-intensive but also makes real-time guidance difficult to achieve, resulting in students wasting significant time on troubleshooting and negatively impacting both lab progress and the learning experience. To address this issue, an AI-powered real-time error localization and debugging system can be introduced to provide students with precise and efficient troubleshooting support. During the experiment, the AI system collects the experiment log files submitted by students in real time. Using natural language processing and network fault feature recognition algorithms, it rapidly analyzes the abnormal information in the logs to accurately pinpoint the error type, location, and root cause—for example, when a log entry states "Unable to establish a connection to the controller," the AI automatically determines whether the issue stems from an unopened controller port, an incorrect IP address configuration, or a controller service that has not been started. It then provides targeted debugging recommendations based on the experimental context, such as "Verify that the controller's IP address matches the configuration in the script" or "Restart the controller service and confirm that port 8080 is listening properly." At the same time, the AI records common error types made by students to build a personalized error database, providing data support for subsequent instructional optimization and targeted student guidance. This helps students gradually master troubleshooting techniques and enhances their self-directed learning and problem-solving abilities.

3.2.4 The introduction and application of virtual simulation platforms

To further enhance the realism and professionalism of laboratory instruction, the Zhiwang OpenLAB virtual simulation platform—developed by the Jiangsu Future Network Innovation Institute—can be implemented to build a highly realistic, scalable network laboratory environment that supports private cloud deployment. Leveraging advanced virtualization technology and core future network technologies, this platform accurately replicates the functions and operational mechanisms of real network devices. It can simulate various complex network scenarios (such as data center networks, wide area networks, and the Internet of Things), enabling students to perform experimental operations in a virtual environment that mirror real-world scenarios, thereby achieving a seamless transition between “virtual practice and real-world application.” The platform supports private cloud deployment, allowing flexible scaling based on the school’s educational needs and hardware resources. This ensures the stability and security of the experimental environment while preventing external network interference. Additionally, the platform offers a rich repository of experimental resources, including various SDN case studies, device models, and protocol templates. Instructors can customize experimental content according to the curriculum, and students can independently select projects for practice, breaking the constraints of time and space to enable experimental learning anytime, anywhere. Furthermore, the OpenLAB platform supports real-time collection and analysis of experimental data. The AI system can integrate platform data to comprehensively evaluate students’ experimental processes, operational standards, and results, providing instructors with precise teaching feedback to facilitate continuous improvement in teaching quality.

In summary, the deep integration of AI technology with the virtual simulation platform has transformed the model of SDN experimental teaching. From environment setup, script generation, and error debugging to hands-on experimentation, it has achieved intelligent optimization across the entire process. This not only reduces experimental costs and lowers the barrier to entry for teaching but also enhances the efficiency and quality of experimental instruction, providing robust support for cultivating network professionals with innovative and practical capabilities.

3.3 Competition-Driven: A Closed-Loop Assessment System That Promotes Learning Through Competition

To further enhance students’ practical application skills and overall competitiveness, we plan to deeply integrate national competitions such as the “Computer Design Competition—Network Technology Challenge” into the course assessment system. We will establish a three-stage training model comprising “preliminary rounds, semi-finals, and finals” to promote learning, practice, and assessment through competition, thereby fostering a deep integration of teaching and practice.

The preliminary round is scheduled at the beginning of the semester and focuses on assessing foundational skills, with an emphasis on evaluating students’ mastery of basic SDN theory and their ability to set up experimental environments. Leveraging the AI-driven automated experimental environment and script generation features developed earlier, students are required to complete tasks such as basic network topology setup and simple protocol configuration within a specified timeframe. This process identifies students with a solid foundation to advance to the semi-finals while helping them quickly review core concepts, thereby laying a strong foundation for subsequent learning and training.

The semi-final module is held in the middle of the semester and focuses on assessing skill enhancement, with an emphasis on evaluating students’ API invocation and secondary development capabilities. Leveraging the virtual simulation platform and AI-assisted tools, students are required to conduct secondary development based on SDN controller APIs in accordance with competition requirements to implement custom network functions and optimize network performance. This cultivates students’ innovative thinking and development capabilities, preparing them for the comprehensive competition in the final stage.

The final round is scheduled at the end of the semester with deep involvement from corporate partners. It features real-world network scenarios aligned with industry practices, focusing on evaluating students’ cybersecurity protection, complex troubleshooting, and emergency response capabilities. Students must apply the experimental operations and debugging skills learned earlier to resolve cybersecurity risks and equipment failures in real-world scenarios, comprehensively testing their practical skills and job readiness.

Through this three-phase training and assessment model, which translates competition standards into educational requirements and integrates industry needs into the training process, students’ ability to apply theoretical knowledge, practical operational skills, and innovative competitiveness are significantly enhanced, thereby fostering high-quality network technology professionals who meet industry demands.

In summary, the deep integration of AI technology with virtual simulation platforms, combined with the restructuring of the competition-driven assessment system, has refined the entire process of SDN experimental instruction. From environment setup, script generation, and debugging to practical assessments, this approach has achieved intelligent and systematic optimization. It not only reduces experimental costs and lowers the barriers to entry for teaching but also enhances the efficiency and quality of experimental instruction, providing robust support for cultivating network professionals with both innovative and practical capabilities.

4. Limitations

Although AIGC technology excels at generating resources, teachers must rigorously review the accuracy of the generated content to prevent “hallucinations” from misleading students.

Competitions often prioritize technical implementation, which can lead to a neglect of systematic theoretical learning in network technology. Therefore, teachers should provide a solid theoretical foundation before the competition to prevent students from becoming mere “technical executors.”

5. Conclusions and Outlook

By establishing a dual-drive model combining “generative AI” and “competition-driven” approaches, this paper effectively addresses the challenges of resource scarcity and the difficulty of setting up experiments in SDN practical training. This model not only enhances students’ practical skills but also provides a new pathway for cultivating network engineering talent. Future research will further explore the application of AIGC technology in cybersecurity education and how to build more immersive virtual experimental environments.

Acknowledgments

Guangdong University of Science and Technology Higher Education Teaching Reform Project” Generative AI + Competition-Driven Empowerment for Innovative Practical Teaching of SDN--A Case Study of SDN Curriculum Reform” Project Number: GKZLGC2025038.

References

[1] Cai J, Luo P, Zheng S, et al. Aigc-enabled Smart Instructional Design for Intercultural Communication Competence Development: A Triadic Human–AI Collaboration Model. World Journal of Educational Studies, 2026, 4(4). DOI:10.61784/WJES3155.

[2] Luke B M, M. K W, Li, et al. ChatGPT for Language Teaching and Learning. RELC Journal, 2023, 54(2):537-550. DOI:10.1177/00336882231162868.

[3] Sun Y C, Liao Y H, Ma X X. Trusting AI to detect AI? A systematic evaluation of the reliability and robustness of current AIGC detection tools for student academic work. Computers & Education, 2026, 249105616-105616.

[4] Xiong Z, Huang Q. A mixed-methods study evaluating student acceptance of artificial intelligence-generated content for sustainable personalized learning in Chinese higher education. Scientific reports, 2026. DOI: 1.0. 1038/S41598-026-46043-6.

[5] Lin L, Chen R. Research on the Reform and Innovation Strategies of College English Teaching from the Perspective of Core Competencies. Curriculum and Teaching Methodology, 2026, 9 (1). DOI:10.23977/CURTM.2026.090124.

[6] Chen Y .Analysis of Teaching Reform in Vocational Mechanical Engineering Programs in the Context of Smart Manufacturing. Curriculum and Teaching Methodology, 2026, 9(1). DOI:10.23977/CURTM.2026.090123.

[7] Tian L ,Wang X, Guo J, et al. Exploration of Teaching Reform of the Course "Photovoltaic Power Station Design and Operation and Control" in Applied Undergraduate Colleges: A Case Study of Shandong Institute of Petroleum and Chemical Technology. Curriculum and Teaching Methodology, 2026, 9(1). DOI:10.23977/CURTM.2026.090120.

[8] Shen K, Sun T, Guo D, et al. AI Empowerment Integrated with Engineering Practice: Pathways and Practices of Teaching Reform in Emerging Engineering Education. Curriculum and Teaching Methodology, 2026, 9(1). DOI:10.23977/CURTM.2026.090119.

[9] Lin X, Liang L .Teaching Reform and Practical Exploration of Robot Path Planning Programming Based on the Artificial Large Language Platform. Advances in Vocational and Technical Education, 2026, 8(1). DOI:10.23977/AVTE.2026.080110.

[10] Fan Y .Construction and Research on the "Generative Inquiry" Teaching Model for

Python Programming Course under the Empowerment of Artificial Intelligence Generated Content. Journal of Modern Educational Theory and Practice, 2025, 2(7). DOI:10.70767/JMETP.V2I7.75.

