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Research and Practice of Blended Learning for Mechanical Fundamental Courses in Military Academy

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Abstract

Practical training education, centered on equipment, is a crucial component in nurturing high-caliber, innovative military talents. To address the shortcomings in the practical teaching of mechanical fundamental courses at comprehensive military technical colleges, we have developed a blended learning-based practical training teaching system, virtual and real teaching resources, and an accompanying evaluation framework. At last, by carrying out the blended case experimental teaching and practical training oriented to the actual combat equipment, the expected teaching practice results have been achieved.

Keywords

Mechanical Engineering, Blended Learning, Virtual and Reality, Teaching Practice

1. Introduction

Engineering training (Chen, Zhu, Wang, & Wu, 2021) is an essential component of higher education engineering programs, playing a vital role in fostering students' engineering acumen, practical skills, and innovative capacities. Similarly, hands-on teaching with military equipment as the object is also an important link to promote the cultivation of high-quality and specialized new military talents.

Currently, in the teaching of mechanical fundamental courses at our comprehensive military technical colleges, issues such as the scarcity of actual installations, high utilization costs, and inherent risks impede practical training, thereby hindering the achievement of teaching objectives that emphasize "equipment orientation and combat readiness" (Wang, 2021). The use of online virtual simulation experiments combined with offline simulation equipment and comprehensive training to carry out practical training and teaching will be able to become an effective means for military colleges and universities to solve the above problems and complete the training of talents.

Now, virtual simulation experiments (Hou, Zhu, Zhang, Li, & Yang, 2022) represent a pivotal trend in contemporary educational technology, effectively addressing the inherent limitations of traditional teaching methods. Recognizing the necessity to align curricula with realistic combat scenarios, institutions have adopted blended learning strategies that integrate virtual simulations with practical training. This integration is particularly crucial for military academies lacking access to live or limited live training conditions, offering an efficient pathway to cultivate skilled personnel. Moreover, it holds significant importance in advancing military training and technological innovation. Additionally, virtual simulations fulfill educational roles that are challenging or unattainable through real-world training alone, adeptly resolving inherent practical issues. Such an approach not only deepens and broadens the scope of practical instruction but also fosters the development of distinguished new military talents.

To achieve the most effective distribution and synthesis of educational assets within mechanical fundamental courses, the convergence of "Internet + Education" provides a framework. This framework leverages the strengths of conventional in-person instruction alongside digital pedagogy. It encourages innovation in didactic approaches and methodologies, capitalizing on the benefits of both online and offline, as well as in-class and extracurricular teaching. The goal is to establish a deliberate, actionable, and progressive strategy for holistic educational development.

2. Blended Learning Concepts and Models

The 2016-2018 Horizon Report (Higher Education Edition) published by the New Media Consortium (NMC) in the United States, strongly endorses blended learning (NMC Horizon Report, 2016, 2017, 2018). According to the report, blended learning has become a model of excellence in talent cultivation, and its design and application will be an important direction for the development of higher education in the future.

In 2000, the Sloan Consortium defined blended learning (Liu, Ye, Li, Zheng, & Chen, 2021) as an integration of face-to-face and online instruction, unifying two previously distinct instructional modalities: traditional classroom teaching and online learning, thereby blending a proportion of online and in-person elements within its framework.

As technology advances and research delves deeper, blended teaching is increasingly recognized for its transformative "learning experience," transcending a mere amalgamation of technologies. It aspires to cultivate an engaging and tailored educational journey for students. The essence of blended teaching lies in its learner-centric approach, which aligns with defined pedagogical goals. It seamlessly merges the intimacy of face-to-face instruction with the flexibility of online learning, thereby enhancing educational outcomes. This modality encapsulates the philosophy of prioritizing student autonomy while acknowledging the instrumental role of educators in guiding, inspiring, and facilitating the learning process. Consequently, it fosters an environment conducive to knowledge dissemination, skill development, and the molding of values.

Serving as a premier institution for cultivating elite military personnel, the National University of Defense Technology is committed to nurturing individuals equipped with the knowledge, competencies, and attributes essential for the modern military landscape (Liang & Xia, 2016). The curriculum is meticulously aligned with the strategic objectives and operational mandates of strengthening our military forces, ensuring a curriculum that is highly relevant, practical, and reflective of the era's demands. This paper delves into the pedagogical strategies for mechanical fundamental courses, examining the integration of virtual and real elements as an entry point for hybrid practical training within the educational framework, thereby enhancing the research and practical application in this domain.

3. Practical Training Teaching System for Mechanical Fundamental Courses Based on Blended Learning

Leveraging a high-quality virtual simulation experimental platform (National Virtual Simulation Experimental Teaching First-class Course) and an experimental environment (National Virtual Simulation Experimental Teaching Center), we have actively implemented blended practical training teaching using anti-tank weaponry and other electromechanical systems as representative cases. We meticulously plan the practical training content, creating an integrated online and offline, in-class and out-of-class, virtual and real teaching environment to compensate for the limitations of real-world training conditions for mechanical fundamental courses. After years of practice and optimization, a hybrid practical training teaching system with distinctive military characteristics has been formed.

As shown in **Figure 1**, the teaching system adheres to a blended learning philosophy that encompasses teaching objectives, practical training content, and the cultivation of comprehensive qualities. It addresses the fundamental questions of pedagogy: how to teach and what to teach, as well as the corresponding student perspectives: how to learn and what to learn. This philosophy permeates the entire process of practical training, seamlessly integrating online and offline, and in-class and out-of-class activities. Furthermore, an evaluation and feedback mechanism for teaching reform is established to foster a symbiotic relationship between assessment and instruction, driving ongoing enhancement.

The left half of the system diagram delineates the specific work planning for teachers, focusing on "How to teach?" This encompasses the development of teaching objectives, a structured teaching plan, online instruction, enhancement of teaching resources, and the establishment of an online platform for Q&A, communication, and discussion. It also includes teaching guidance, evaluation, and the ongoing optimization of teaching reform. The right half outlines the students' learning plan, centered on "How to learn?" This involves setting clear learning objectives, fostering independent learning, facilitating communication and interaction, incorporating virtual practice, and conducting teaching evaluations. The central section details the teaching content, which is aligned with the teaching objectives and the goals of comprehensive quality development. It spans three levels of practical training: foundational, comprehensive, and innovative, and is integrated with the course on Civic and Political Development, exemplified by the equipment case study. The upper section pertains to online teaching, featuring a modular system designed to support personalized learning, grounded in virtual environments (Wu, Wang, Zhang, & Cui, 2019). The latter part addresses offline teaching planning, which blends virtual and real elements to complement the comprehensive training approach.

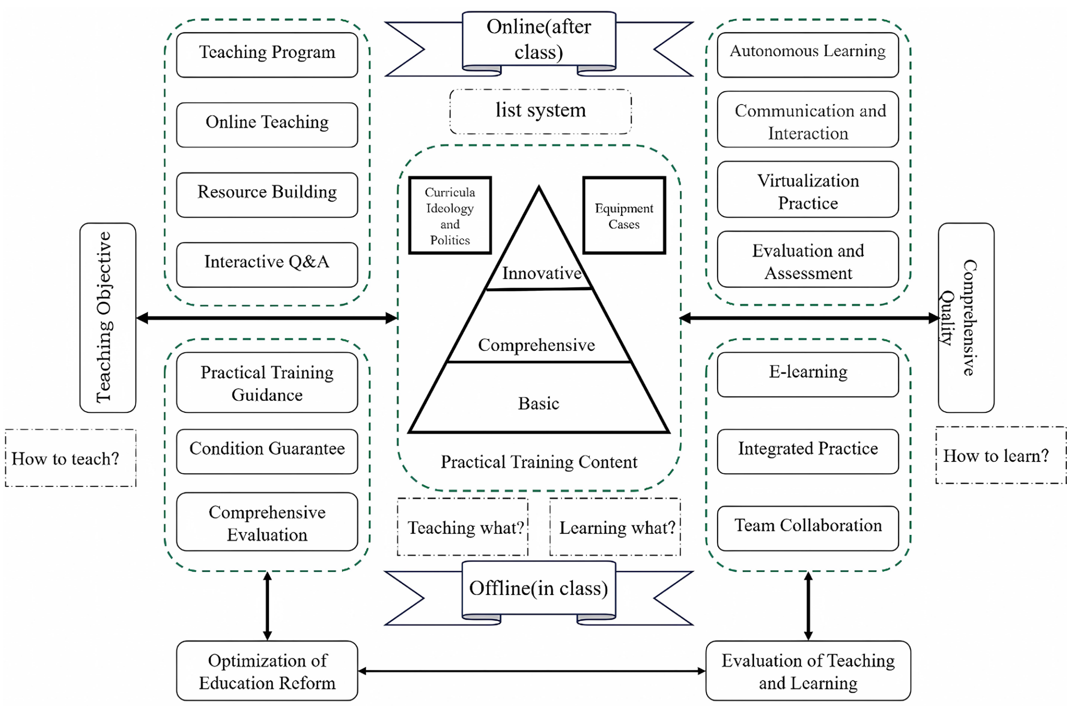

Figure 1. Equipment principle blended practical training teaching system for mechanical fundamental courses.

To ensure the seamless execution and high quality of blended teaching, efforts are made to develop a faculty adept in blended teaching, characterized by profound theoretical knowledge, extensive teaching experience, and robust practical abilities. We foster in-depth collaboration with third-party organizations to ensure the professionalism and efficiency of teaching resource development and the secure, stable operation of the teaching platform. Teachers are encouraged to engage proactively in pedagogical research and reform, meticulously design training programs, and diligently plan teaching tasks. They are also urged to continuously enhance online and offline teaching resources and conditions, excelling in teaching practices such as guidance, interactive Q&A sessions, and assessments. Students are motivated to pursue independent study and comprehensive practice, fostering an academic environment that blends online and offline, in-class and out-of-class research and practice. This approach aims to nurture students' team spirit and collaborative skills, and to extensively implement various teaching methods, such as simulation-based, case-based, research-oriented, and problem-based teachings, integrated with the course's ideological and political perspectives, in a continuous quest for organic integration of diverse pedagogical approaches.

4. Construction of Practical Training Teaching Resources for Mechanical Fundamental Courses

To meet the teaching needs of the mechanical fundamental course, grounded in the principles of equipment, we have conducted an in-depth study of the principles and essence of blended teaching. We continuously optimize the teaching content, focusing on the core knowledge of practical training teaching across three levels: basic, comprehensive, and innovative (Xie, Zhang, Sun, Zhao, Yang, Xu, Gu, & Song, 2024). Utilizing a structured, modular approach that integrates virtual and real elements, we systematically plan and construct relevant practical training teaching resources, encompassing both online (virtual-based, as shown in Table 1) and offline components (a blend of virtual and real, as shown in Table 2).

Table 1. List of online teaching resources for mechanical fundamental courses.

NO	Resource Name	Practical Training Program	Knowledge Points	Resource Type	Courses Applied
1	Anti-tank weapon simulation system	Anti-tank weapon simulation system working principle experiment	Analog System Structure and Principle	Basic	(1) Fundamentals of Mechanical Design, (2) Fundamentals of Mechanical Design B, (3) Fundamentals of Engineering Drawing, (4) Fundamentals of Engineering Drawing B, (5) Analysis and Design of Equipment Electromechanical Systems, etc.
2	Typical shaft system structure of an analog system	Axis system design and analysis experiment	Shaft construction, tolerances and fits, assembly processes	Basic	
3	Analog System Pitching Mechanism	Tilting device assembly structure analysis and assembly drawing experiment	2-axis motion components, servos, assembly drawings	Basic	
4	Typical Encoder Structure	Encoder principle and application experiment	Encoder structure and principle, typical applications	Basic	
5	PWM Driver Circuit	DC motor PWM drive principle and characterization experiment	PWM principle, driver circuit structure and electrical characteristics	Basic	
6	PID parameter control	Photoelectric search system PID control experiment	PID parameters, PID regulation and system characterization	Basic	

Table 2. List of offline teaching resources for mechanical fundamental courses.

NO	Resource Name	Practical Training Program	Knowledge Points	Resource Type	Courses Applied
1	AC servo systems, mechanical actuators and experimental software	AC servo system motion control	AC servo motor structure and principle, servo control	Comprehensive	(1) Fundamentals of Mechanical Design, (2) Fundamentals of Mechanical Design B, (3) Fundamentals of Engineering Drawing, (4) Fundamentals of Engineering Drawing B, (5) Analysis and Design of Equipment Electromechanical Systems, etc.
2	Digital PID experiment platform and experiment software	Digital PID system control	PID parameters, PID regulation and system characterization	Comprehensive	
3	Two-coordinate numerical control table and experiment software	Interpolation principle	Principle of interpolation, trajectory control	Comprehensive	
4	DC motor servo control systems, drive loads and regulation mechanisms	Dynamic parameter testing of mechanical systems	Dynamic parameters and testing, loading and regulation	Comprehensive	
5	Fire-control radar simulation system, follower experimental mechanism	Radar follower servo control	Follow-through control and simulation exercises	Comprehensive	
6	Guide head simulation system, target simulation system	Stabilized tracking of imaging guides	Guide head structure and principle, simulation exercise	Comprehensive	
7	Vehicle-mounted weapon simulation system, target and field effect simulation system	Vehicle-mounted weapon systems integrated exercise	Principles of vehicle-mounted weapon systems and simulation exercises	Comprehensive	
8	Offshore motion platform simulation system, lifting simulation system	Comprehensive exercise for lifting and stabilizing platforms at sea	Motion compensation and simulation exercises	Comprehensive	
9	Thermal imaging camera detection components, stabilization platforms	Optical pod simulation manipulation	Optical pod structure principle and simulation exercise	Comprehensive	
10	Detection devices, communication modules	UAV mission payload	Mission Load and Characterization	Comprehensive	

In the development of our educational resources, we have meticulously incorporated the latest scientific research findings, creating a robust set of online and offline practical training materials. These materials cover the fundamental principles of various military technologies, including anti-tank weaponry, radar systems, guidance heads, photoelectric pods, and additional related equipment. Notably, the virtual simulation comprehensive experiment for the anti-tank weaponry electromechanical system employs multimedia techniques such as sound, light, and projection to create a dynamic combat scenario. This simulation includes a full range of combat processes, from target search and tracking to weapon system guidance, laser pointing, control handling, and the assessment of target engagement and impact effects. Such an integrated approach effectively addresses the requirements of practical training and instruction.

The network-based unit principle experiments, with a focus on anti-tank weaponry, are designed to conduct foundational studies on the principles of common mechanical transmission devices, servo components, and detection and control systems. These experiments are highly versatile and utilize virtual-based formats that are easily accessible on network platforms, facilitating learning. For instance, experiments involving the anti-tank weaponry electromechanical system, as depicted in Figure 2, employ three-dimensional animations to demonstrate the principles of structure and assembly of typical components. Through virtual disassembly and assembly exercises, students engage in the analysis of typical mechanisms and structures, fulfilling the objectives of online practical training and teaching.

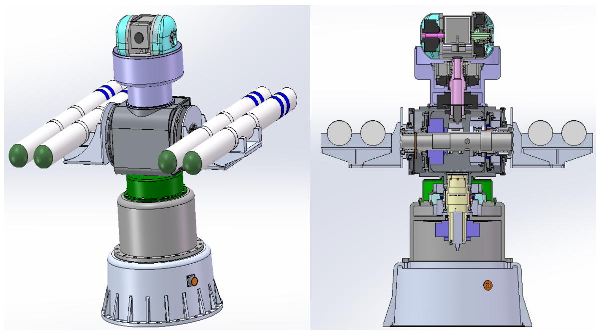

Figure 2. Principle structure and virtual assembly of typical components on the line.

The comprehensive system simulation experiment is grounded in real-world application technology, aiming to construct a simulation platform for anti-tank weaponry that closely mirrors actual combat scenarios, and its structural composition is shown in Figure 3.

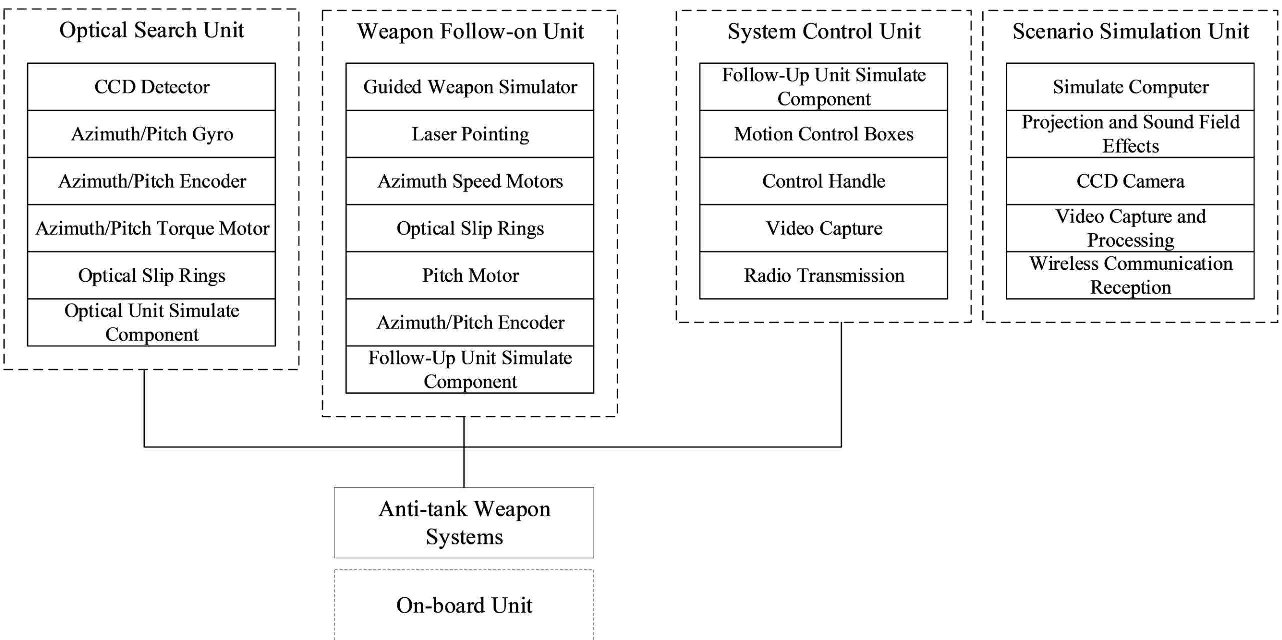

Figure 3. Structural composition of the simulation experiment platform for anti-tank weapons and equipment.

Experiments employ a hybrid approach, merging real and virtual elements to conduct anti-tank combat simulation exercises, as shown in **Figure 4**, the vehicle unit simulation carries a photoelectric search, weapon follower unit and the system control unit, the scene simulation unit to generate a dynamic virtual combat environment and hit the target, through the control unit to simulate the search and target identification, the weapon follower unit carries a laser pointing to the target, by the control unit to control the weapon aiming and firing, the scene simulation unit virtual simulation weapon strikes and effect evaluation. Scenario simulation unit virtual simulation weapon strikes and effect evaluation, the experimental process focuses on simulation and training close to the actual installation technology.

Figure 4. Offline simulation integrated training platform.

5. Evaluation System of Blended Practical Training Teaching

In compliance with the established guidelines for the development and application of virtual simulation in experimental teaching, we have integrated the distinctive elements of blended practical training within mechanical fundamental courses to create a comprehensive evaluation framework. This framework is founded on the principles of diversity, plurality, and feasibility. The evaluation system prioritizes the learning process, which includes the acquisition of knowledge, the development of skills, and the nurturing of appropriate affective attitudes and values. It is meticulously crafted to evaluate student performance across online and offline environments, encompassing the three pivotal phases: pre-course, in-course, and post-course. The framework places a significant emphasis on pre-course guidance and preparation, fostering an environment that encourages students to engage in experimental projects with autonomy, collaboration, and curiosity, and to extend their explorations according to individual interests. With a focus on pre-course guidance and initial experimental assessments, the system advocates for students to independently and cooperatively undertake exploratory projects, tailored to their personal interests. It conducts a comprehensive evaluation that includes pre-testing, practical operations, experimental data analysis, and the quality of experimental reports, thereby assessing the effectiveness of the student's learning and practical training. For specific details, refer to **Figure 5**.

Online Learning Evaluation				
Evaluation Indicators	Self-learning	Inspection and Testing	Virtual Experiment	Experimental Report
Evaluation Content	Watch the Video	Learning Assessment	Process Recording	Principles and Methods
	Demonstration Teaching		Experimental Data	Process Overview
	Reading Material		Innovative Practices	Experimental Summary
Percentage	20%	20%	40%	20%

Offline Learning Evaluation		
Evaluation Indicators	Field Experiment Performance	Experimental Report
Evaluation Content	Attendance	Completeness
	Attitude	Normative
	Performance	Innovativeness
	Mandate Completion	Correctness
	Innovative and Collaboration	
Percentage	40%	60%

Percentage of online learning evaluation	Percentage of offline learning evaluation
30%~80%	20%~70%
Composite Grade of Blended Practical Training Teaching	

Figure 5. Evaluation system of blended practical training teaching in mechanical basic courses.

The online evaluation primarily encompasses independent learning, assessment through measurement tests, virtual experiments, and the submission of experiment reports. The offline evaluation focuses on attendance, emotional engagement, the experimental process, outcomes, the demonstration of innovation and collaboration, and the quality of the experimental report. The online experimental platform automatically captures data related to the experimental process and outcomes. It utilizes operational assessments and question-and-answer evaluations, with a focus on the sequence of operations, conditions, and the progression of experimental results.

The platform supports two modes of evaluation: “Automatic Grading by System” and “Manual grading by instructors online”. “Automatic Grading by System” refers to the process where the system autonomously identifies scoring criteria from the experiments, aligns them with grading rules, and computes the scores. “Manual grading by instructors online” allows teachers to review the system’s automatic grading outcomes and related experimental data, and to perform manual grading as needed, a method often utilized for innovative experiments. Manual grading serves as a corrective mechanism for the system’s automatic grading and is commonly employed in the evaluation of innovative experiments.

The comprehensive evaluation of blended practical training teaching can be tailored to the specific curriculum, content, and instructional arrangements. It involves determining the proportion of online and offline components in the practical training teaching and their respective grading contributions, culminating in the compilation of the student’s overall practical training outcomes.

6. Teaching Practices and Effectiveness of Blended Practical Training Teaching

Throughout our teaching practice, we have consistently embraced a reformative and developmental philosophy encapsulated by "establishing a solid foundation, emphasizing practical application, and nurturing innovation". Against the backdrop of military applications within large-scale engineering, we have integrated course ideology and politics into equipment case studies, thereby crafting a blended practical training teaching system with distinctive military characteristics. Over the years, we have persistently refined the development of the National Virtual Simulation Experimental Teaching Center for "Electromechanical Engineering and Automation" and the National Virtual Simulation Experimental Teaching First-class Course, exemplified by the "Anti-Tank Weaponry Electromechanical System Virtual Simulation Comprehensive Experiment". This includes enhancing online and offline practical teaching resources and training. Offline practical teaching resources and training conditions effectively promote the sharing of quality resources, forging a high-quality faculty that meets the requirements of blended practical training and teaching.

We have introduced an innovative operational and managerial paradigm for experimental teaching, which includes virtual experiment preparation, online booking, on-site engagement, automatic process monitoring, and real-time effect assessment, thereby establishing a fully open, student-centered experimental environment. By incorporating modern virtual simulation experimental methods and technologies, we have established a virtual-real integration approach that emphasizes real-world applicability and combat-oriented teaching. This approach brings weaponry and equipment into the classroom, enabling the completion of teaching functions that are otherwise unattainable or challenging in real experiments. It effectively addresses the practical challenges of experimental teaching and enhances the depth and breadth of experimental education. For instance, in the teaching practice of anti-tank weaponry, we leverage the strengths of multidisciplinary integration and fully utilize the collaborative advantages of school-enterprise partnerships in information technology resources. This enables the virtual disassembly of real equipment, animated simulations, analytical simulations, and practical simulations, achieving a safe and economic fulfillment of teaching functions that are otherwise absent or challenging in real experiments. This effectively extends and expands upon traditional teaching methods, transcending the limitations of time and space in conventional education. It significantly broadens the scope for student-initiated innovation and practice, thereby effectively stimulating students' enthusiasm for learning. Supported by the virtual simulation experimental platform and laboratory simulation environment, students are empowered to organize their own experiments and conduct repeated operational exercises. They can even formulate their own experimental topics, utilizing the existing virtual simulation system to execute their designed experimental content, which allows for multiple iterations of experimentation and practice. This novel experimental model eschews traditional didactic teaching, fostering independent student participation in the learning process, thereby maximizing their initiative and creativity.

At presently, this practical training and teaching program has been extensively integrated into the pedagogical practices for mechanical engineering and related majors at our university. It encompasses a range of foundational mechanical courses, including Fundamentals of Mechanical Design, Fundamentals of Mechanical Design B, Fundamentals of Engineering Drawing, Fundamentals of Engineering Drawing B, and the Analysis and Design of Equipment Electromechanical Systems, which have been used to provide a practical environment and a research platform for the nearly ten undergraduate graduation design, and to provide a quality innovative practice platform for the college students to carry out disciplinary competitions, extracurricular scientific and technological activities etc. It offers a platform conducive to high-quality innovation and practice, playing a pivotal role in nurturing high-caliber new military talents.

7. Conclusion

The convergence of diverse teaching methodologies represents a pioneering transformation within tertiary education, igniting a significant upsurge in scholarly inquiry and empirical investigation. This integration has catalyzed the emergence of a novel educational paradigm that seamlessly blends online and offline instruction, leveraging the distinct advantages and inherent irreplaceability of both formats to achieve a synergistic outcome where the collective efficacy is greater than the individual contributions (1 + 1 > 2). As we embark on this formidable journey, akin to forging iron, the directives from the Party Central Committee underscore the development of an innovative military training system. This system is anchored in a tripartite approach encompassing military academy education, practical troop training, and military vocational education. The initiative's scope extends beyond academic institutions, promising to significantly enhance the impact on practical troop training and military vocational education.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

2016 NMC Horizon Report.
https://library.educause.edu/resources/2016/2/2016-horizon-report

2017 NMC Horizon Report.
https://library.educause.edu/resources/2017/2/2017-horizon-report

2018 NMC Horizon Report.
https://library.educause.edu/resources/2018/8/2018-nmc-horizon-report

Chen, J., Zhu, L. C., Wang, J., & Wu, J. B. (2021). Research on Engineering Training Innovative Practical Course System Under the Background of New Engineering. *Experiment Science and Technology, 19,* 84-88.

Hou, H., Zhu, S. H., Zhang, Q. Y., Li, X. S., & Yang, X. (2022). An Overview of the Development of Virtual Simulation Experiment in Universities. *Journal of Electrical and Electronic Education, 44,* 143-147.

Liang, L. M., & Xia, Y. Y. (2016) Status, Barriers, Motivations, and Implications of Online Education in the U.S. Higher Education: Based on the Analysis of 12 Years Survey Reports from Sloan-Consortium. *Open Education Research, 22,* 27-36.

Liu, S. K., Ye, Y. C., Li, Y. J., Zheng, M. C., & Chen, X. Y. (2021) Research on Engineering Talent Cultivation Pans in Military Academy Based on Concept of Emerging Engineering for Strengthening the Army: The Case of the Talent Cultivation Plan of Material Science and Engineering (Test and Evaluation Technology Wind Tunnel). *Journal of Higher Education Research, 44,* 114-120.

Wang, Y. (2021). Exploration and Analysis of Actual Combat Teaching in Military Academies under the Background of "Educating People for War". *Advances in Social Sciences, 10,* 16-19. https://doi.org/10.12677/ass.2021.101004

Wu, C. L., Wang, L. Q., Zhang, J. S., & Cui, X. R. (2019) Application of SPOC Mixed Teaching Mode in Comprehensive Practical Courses. *Research And Exploration in Laboratory, 38,* 153-157.

Xie, B. H., Zhang, G. J., Sun A. P., Zhao, T. S., Yang, Z. S., Xu, Z. S., Gu, Y. R., & Song, X. F. (2024) Analysis of Factors Affecting Students' Academic Performance under Blended Teaching Model-Taking Medical Immunology Course as an Example. *Chinese Journal of Immunology, 40,* 828-831.