Reform and Practical Exploration of the "Application-Plus" Teaching Model for Radar Equipment

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Abstract. Aiming at the problems of "over-technicalization, proceduralization, and classroom-bound practice" in traditional radar equipment teaching, this paper proposes a reform of the "Application-Plus" teaching model. A four-driver integrated reform framework is constructed: optimizing teaching content through "three novelties, three strengths, three proximities"; deepening the technical-application coupling through "tripartite collaboration, multi-track progression, and scenario-embedded resident training"; reconstructing teaching platforms through "three high-fidelity features, two integrations, one embedding"; and rebuilding assessment through "full-dimensional full-state evaluation, training-assessment fusion, and three-level vertical coherence." Practice shows that cadets achieve significant improvement in scenario decision-making, emergency equipment repair, and equipment operation, while satisfaction rates of both cadets and employing units rise markedly. The results verify the scientific validity and generalizability of the four-driver reform path and provide a systematic new paradigm for talent cultivation for equipment application.

Keywords: radar equipment teaching, application-plus, employment-instruction coupling

1 Introduction

With modern radar equipment evolving rapidly toward informatization and intelligence, operators' radar application capability has become the key to timely and accurate air-situation awareness. The continuous advancement of aircraft technology and performance makes the air situation increasingly complex, imposing higher demands on radar equipment application teaching and training.

As the core force of air-situation perception, radar equipment's support and application capability directly determines operational effectiveness; therefore, equipment teaching must adhere to the principle of "training consistent with employment, and employment leading instruction." In recent years, various academies have sustained efforts in equipment teaching reform, achieving remarkable results in standardizing instruction and improving talent quality. For example, Ref. [1] proposed a hands-on practical teaching model and verified its effect on improving cadets' certification rate; Ref. [2]

© The Author(s) 2026
M. B. Badzis et al. (eds.), *Proceedings of the 2026 2nd International Conference on Education Research and Training Technologies (ERTT 2026)*, Advances in Social Science, Education and Humanities Research 1042,
https://doi.org/10.2991/978-2-38476-628-4_16

proposed a "three-stage progressive" practical teaching model to solve the difficulty of teaching new equipment; Ref. [3] applied information technology to radar equipment courses; Ref. [4] promoted the transformation of radar equipment knowledge into practical application; Ref. [5] applied chain-of-questions pedagogy; Ref. [6] applied blended teaching to airborne radar courses; Ref. [7] standardized radar fault-troubleshooting course teaching; Ref. [8] adopted differentiated grouping and flexible task design.

However, no targeted systematic teaching method has yet been formed for cultivating compound radar equipment application talents, and shortcomings remain in comprehensively improving cadets' post-incumbency and radar equipment application capabilities. The following sections propose a teaching-model reform method against concrete practical problems to enhance the quality and effectiveness of radar equipment courses.

2 Practical Problems

Facing the compound capability requirements of "fast response, precise operation, capable coordination, and innovative adaptation" for radar equipment talents under modern air-situation perception tasks, three prominent contradictions persist in current radar equipment teaching: teaching content is "over-technicalized," teaching mode is "proceduralized," and training platform is "classroom-bound," leading to a disconnect between talent cultivation and actual demands.

2.1 Teaching Content "Over-Technicalized"

Current radar equipment courses emphasize principles over application, lacking deep linkage with equipment application mechanisms, application scenarios, and complex air-situation environments. Maintenance teaching lacks emergency repair training; application teaching lacks group gaming and real-case deduction, resulting in cadets who "understand mechanisms and can operate" but "struggle to adapt and are poor at application." In the "radar fault elimination" subject, traditional teaching only focuses on fault localization and repair procedures, without setting actual special situations such as "emergency repair after sudden radar failure," causing a lack of decision-chain training in real environments.

2.2 Mode and Method "Proceduralized"

The teaching mode remains dominated by "lecture–demonstration–practice," with mechanical theory-practice fusion and superficial virtual-real fusion. Insufficient use of post-experience means makes it difficult to stimulate cadets' autonomous inquiry and adaptive response, undermining high-order capability cultivation. "Proceduralization" refers to highly rigid teaching flows where cadets operate step-by-step, lacking elastic training for non-predetermined environmental situations.

2.3 Training Platform "Classroom-Bound"

The teaching platform is mostly "classroom equipped with devices," failing to reproduce real environments such as electromagnetic interference, unidentified air situations, and sudden failures, causing a "two-skin" phenomenon where "training looks right in class but fails in practice." Surveys show that most existing simulation training platforms operate in single modes and cannot construct complex training environments with natural environments and dynamic target RCS variation, leading to long cycles and poor outcomes in cultivating application capability during practical training.

3 Reform Path

This reform is supported by constructivism learning theory, Competency-Based Education (CBE), and "learning by doing." Targeting the realities of "over-technicalization, proceduralization, and classroom-bound practice," this paper proposes the "Application-Plus" teaching model reform, driven by task demands and centered on cultivating cadets' radar equipment application capability. By breaking the shackles of traditional teaching philosophy and establishing the theory-practice fusion concept of "application-demand drive, technical-capability support," a new curriculum teaching paradigm with "application orientation" as its core is formed. Its essence is to take the generation of radar equipment application capability as the traction, inject the gene of "application" into every teaching link, and realize the fundamental shift from "teaching equipment" to "teaching application." Around this concept, this paper constructs a "four-driver" reform path, whose logical relationship is shown in Figure 1.

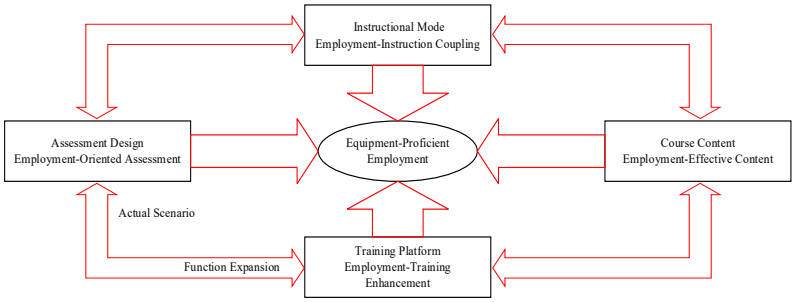


Fig. 1. Logical relationship diagram of the four-driver reform path.

A closed-loop architecture centering on the generation of "proficient-employment-and-combat" capability defines the final competencies cadets should possess. It connects the full chain of content-mode-platform-assessment: content leaps from technology to combat, mode upgrades from routinization to combat-instruction coupling, platform reshapes from classroom-bound to battlefield-oriented, and assessment transforms from knowledge to capability. The four drivers mutually support each other—content reconstruction is the foundation, mode innovation the key, platform build-up the support, and assessment reform the guidance—all serving the goal of generating "proficient-employment-and-combat" capability.

3.1 Implementing "Three New, Three Strong, Three Close" to Enhance Teaching Content

Based on the course characteristic of "teaching for use, integrating technology with application," we propose the "Three New, Three Strong, Three Close" measures to iteratively update radar equipment operation content, shifting from a "technology-centered" to an "application-plus" paradigm.

First, "Three New": keep pace with new equipment, technologies, and tactics. Establish a "follow-research, follow-production, follow-training" mechanism to prepare for new equipment instruction in advance. Integrate frontier technologies like intelligent signal processing and adaptive beamforming into materials for dynamic updates. Extract new tactics such as "distributed network detection" and "multi-source jamming countermeasures" from exercises, updating the three databases (exercise, real-case, scenario) to align teaching with practice.

Second, "Three Strong": strengthen correlation between content and objectives, integration of cases with real scenarios, and relevance of modules to equipment application. Build a "competency–content–task" mapping model. Embed a four-step process—"real background, threat analysis, decision simulation, effect evaluation"—into case teaching. Add scenario modules like "optimized equipment deployment" and "emergency anti-jamming" to textbooks to enhance learners' sense of presence.

Third, "Three Close": close alignment with job positions, daily training, and exercises. Design full-process basic training covering "startup, parameter setting, target identification, fault handling" based on duties. Develop specialized drills for shift support, such as "nighttime sudden faults" and "electromagnetic interference attacks." Address weaknesses like poor coordination and slow response through comprehensive simulations. Create loose-leaf textbooks updated twice per semester, incorporating hands-on experience and instructor insights. These measures boost both the "novelty quotient" and "applicability quotient" of content, enhancing knowledge transfer.

3.2 Expanding "Tripartite Collaboration, Multi-Track Progression, Scenario-Embedded Resident Training" to Drive Technical-Application Coupling in Teaching Mode

Based on the goal of generating equipment application capability, "tripartite collaboration" consolidates the educational synergy of academy, employing unit, and equipment manufacturer; "multi-track progression" builds a gradual training system for practical skill training and radar equipment operation; "scenario-embedded resident training" promotes teaching embedded in actual scenarios, facilitating cadets' shift from "can operate" to "good at application" and from "single-party cultivation" to "collaborative co-education," ultimately realizing the deep coupling of "personnel and equipment, capability and application."

First, "tripartite collaboration" cultivates talents and improves equipment application capability. The three parties clarify division of labor: the academy focuses on equipment principles, operation, and support teaching; the employing unit provides real

scenarios and capability standards; the research/manufacturing institute provides technical support and virtual training systems. A linkage mechanism is established to align courses with the employing unit's training plan, jointly building an "academy–employing unit–manufacturer" resource repository for real-time sharing of textbooks, cases, and data, forming a "demand" teaching "verification" "optimization" closed loop. Focusing on application shortcomings, through joint platforms and normalized exchange, the path of "post experience + application verification" is implemented to improve capability transformation efficiency.

Second, "multi-track progression" tempers capability and promotes the application-oriented transformation of teaching. Construct a teaching system of "one main line + two branch lines." The main line anchors direction with "equipment principle" equipment support "equipment application" as the teaching axis. Branch lines include the horizontal instructional line and the vertical practice line. The horizontal line follows progressive steps, decomposing the three major modules into stair-step teaching units; the vertical line strengthens capability through the "three-stage progressive" training of "basic skill general training – special capability intensive training – comprehensive application deep training."

Third, "scenario-embedded resident training" strengthens literacy and maximizes technical-application coupling. Through "precise scenario seeking–hierarchical resident training" "achievement transformation," cadets temper equipment application capability in real scenario environments. Precise scenario seeking identifies teaching shortcomings through the three-dimensional channels of "employing unit visit"drill follow-up"data analysis"; hierarchical resident training sets three-level training of "basic"advanced"application"; achievement transformation converts the "operation tricks" and "application insights" distilled during resident training into teaching content, realizing the purpose of "promoting teaching through application and strengthening application through teaching."

3.3 Strengthening "Three Realisms, Two Connections, One Integration" for Platform-Based Training Quality

To address limited scenario realism and incomplete practical subjects, we develop a comprehensive platform bridging classroom, real equipment, and simulation systems, integrated into the institute's unified training environment.

First, develop a "three-realism" teaching platform for full-element simulation. Targeting difficulties in survivability drills, fault settings, and scenario construction—which hinder higher-order skills like strategy and coordination—we create a platform that realistically reproduces equipment, scenes, and adversarial conditions. The "external radiation source environment generation system," independently developed, injects scenario-specific electromagnetic signals into real radar in real time, overcoming simulator signal rigidity.

Second, realize "two connections" to multiply effectiveness. Classroom-to-equipment connection: modify interfaces for real-time command mapping and status feedback; integrate terrain, weather, and electromagnetic data for dynamic difficulty adjustment. Platform-to-system connection: unify data from simulators, real equipment, and

situation assessment systems to create a multi-platform collaborative training environment, fostering systematic early-warning and coordination capabilities.

Third, implement "one integration" for system linkage: use the scenario-based training field and external radiation source system as a bridge to convert actual information into electromagnetic signals perceptible by real radar. Radar returns feed back to the assessment system, forming a "sense–decide–act" closed loop, elevating radar operation from single-unit to system-of-systems application.

3.4 Creating the "Full-Dimensional Full-State, Training-Assessment Fusion, Three-Level Coherence" Assessment Mode to Drive Assessment Toward Evaluating for Practical Application

Adhering to the concept of "focusing on application, closely following posts, training-assessment consistency, and shaping capability through assessment," aligning with employing unit incumbency demands, highlighting radar equipment application characteristics, and centering on improving learning effectiveness, assessment is treated as a key link in equipment teaching, empowering the whole course teaching process and promoting the shift of assessment from knowledge testing to capability generation.

First, based on new-quality capability requirements, construct the "full-dimensional full-state" capability index. Establish an index system covering the "full-state support capability" across the equipment full-lifecycle, full-state pedigree, and full-scenario environment, and the "full-dimensional application capability" of flexibly using equipment in multi-dimensional spaces (physical domain, information domain, cognitive domain), running through the whole teaching process and realizing "assessment toward application."

Second, based on course content reform, construct the "training-assessment fusion" assessment content system. Adhering to teaching-assessment consistency, dynamically aligning with employing unit training subjects, integrate contents such as "comprehensive application of equipment theory, emergency fault handling, coordinated networking detection" into assessment, driving teaching from "knowing principles, being able to operate" to "being able to apply, good at coordinating" and realizing assessment due to application.

Third, based on constructivism theory, design the "three-level coherence" assessment method. Implement the closed-loop assessment of "three-phase daily test, two-phase stage exam, one integrated terminal evaluation." The "three-phase daily test" accompanies the teaching process with real-time feedback; the "two-phase stage exam" verifies phase achievements and optimizes learning paths; the "one integrated terminal evaluation" integrates the actual scenarios of coordinated application to test the level of "understanding strategies, being able to apply."

Through "full-dimensional full-state" setting standards, "training-assessment fusion" establishing content, and "three-level coherence" promoting implementation, assessment and teaching resonate at the same frequency, empowering equipment talents to cross from "being able to operate" to "being good at application."

4 Teaching Practice

To scientifically evaluate the reform effect, the "Application-Plus" teaching reform has been piloted in radar equipment course teaching of relevant specialty cohorts, adopting a quasi-experimental research design.

Table 1. Comparison of "Combat-Plus" reform effects.

Comparison item	Traditional group (%)	Reform group (%)	Improvement (%)
Scenario decision accuracy	*74.2*	*89.3*	*15.1*
Equipment repair completion rate	*76.2*	*91.7*	*15.5*
Equipment application accuracy	*72.2*	*85.4*	*13.2*
Cadet satisfaction	*85.4*	*93.2*	*7.8*
Employing-unit satisfaction	*88.1*	*96.5*	*8.4*

Two teaching cohorts under the original teaching model were selected as the traditional group, and three teaching cohorts implementing the "Application-Plus" reform in the 2024–2026 academic years were selected as the reform group. The two groups showed no significant difference in entrance basic scores and pre-course average scores, confirming comparability. Among them, scenario decision accuracy was obtained through decision-node scoring in group gaming; equipment repair completion rate was based on timed real-equipment fault elimination and success rate; equipment application accuracy was scored from operation norms and application scoring in equipment operation; cadet satisfaction used a five-level scale questionnaire; employing-unit satisfaction was evaluated by receiving units on the internship performance of graduating cadets. The comparison of "Application-Plus" reform effects is shown in Table 1.

Combining formative and summative assessment, cadets achieved leapfrog improvement in the three core dimensions-battlefield decision, fault diagnosis, equipment employment-with significant instructional effect. Moreover, 93.2% of cadets judged reformed content closer to unit reality; post-experiential mode notably raised learning interest; virtual-real fusion platforms strengthened combat feel; formative and summative assessments approximated real combat, with obvious "assess-to-learn" effect. Comprehensive analysis verifies the scientific soundness and effectiveness of the four-driver path.

5 Conclusion

The main innovations of this paper include: first, proposing for the first time the "application-orientation" radar equipment teaching philosophy and constructing the "four-driver" integrated reform framework, realizing the full-chain reshaping of teaching toward application; second, creating the original "scenario-embedded resident training" technical-application coupling mode, deeply embedding real environments with teaching through the path of "precise scenario seeking"hierarchical resident training"achievement transformation," which is first proposed by this team and matured in multiple cohort pilots; third, independently developing key components of teaching platforms such as the complex-environment generation system, breaking the barrier between classroom and real environment.

The "Application-Plus" teaching reform is an inevitable requirement of educational modernization in the new era. On the basis of systematically solving the problems of "over-technicalized" teaching content, "proceduralized" mode, and "classroom-bound" platform, this paper constructs the "four-driver" integrated reform idea, realizing cadets' fundamental shift from "learning for examination" to "learning for application." The reform practice shows that the "Application-Plus" philosophy has high scientific validity, systematicity, and generalizability. In the future, the integration of AI+ technology will be further deepened to construct new teaching tools such as intelligent knowledge graphs, AI teaching assistants, and virtual instructors, promoting teaching toward intelligent, personalized, and precise development.

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