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Wargaming as a Pathway to Engineering Practice Ability and Innovative Thinking in Vocational Communication Education

Zihao Jin*, Beiping Wu, Shikai Wu, Yue Yu, Yuze Song
PLA Air Force Communications NCO Academy, Dalian, Liaoning, China
**Corresponding Author*

Abstract. With the increasing informatisation and intelligence of modern warfare, communication support directly affects combat effectiveness, and therefore, vocational communication programs are now under pressure to cultivate graduates with stronger engineering application capabilities and innovative thinking. Teaching in this area still lacks practice scenarios that connect with real-life operations, the teaching model is inflexible, and there are too few vehicles for innovation development. Wargaming is a kind of instruction that creates high-fidelity and adversarial interaction environments, and it will be employed in this paper to build complex communication-support scenarios closely related to real operations and provide students with an authentic decision-making space. This paper identifies the teaching problems, explains the working mechanism of wargaming, and proposes an implementation plan for communication majors. The proposed pathway is expected to enhance students' ability in operationally-based engineering practice and innovation, and it provides a reference for practice-oriented reform of communication education.

Keywords: Wargaming; Vocational Communication Education; Engineering Practice Ability; Innovative Thinking

1. Introduction

A communication network is no longer a passive channel for the transmission of signals. It is the core that ensures the timely transmission of information and the correct delivery of orders. Emergency support needs to rebuild command links quickly after roads are cut and power is out. Large-scale public events require communication services of high quality in the event of extreme crowding and sudden traffic surges. The essential nodes of the battlefield need to maintain connection under severe electromagnetic interference and equipment failure. Although the physical conditions of these environments are different, the demands on the people who work in them are very similar: to reach an executable judgment under conditions of incomplete information, time pressure and scarce resources, and then promptly correct that judgment if it is found to be erroneous.

This requirement goes far beyond the narrow skill of equipment operation. The Outline of the Plan for Building a Strong Education Nation (2024-2035) places the cultivation of high-quality talent at the core of the new vocational education system, and the Action Plan for Improving Quality and Cultivating Excellence in Vocational Education (2020-2023) has specifically required vocational schools to strengthen the practice-teaching model [1]. This policy orientation is rooted in a more fundamental judgement. What the industry sites need are not skilled hands to carry out orders, but technical decision-makers who can take responsibility for technical outcomes.

Vocational communication programmes are one of the sources for these people. They have a short training cycle, practical orientations, and most graduates are immediately deployed to front-line positions in communication operations and maintenance, engineering construction or emergency support. The reform of teaching at this level will then be able to reach the front lines promptly and directly after a suitable entry point is found. This paper aims to determine whether the current practice-teaching system can effectively promote the formation of this structure of composite abilities.

2. Persistent Difficulties in Cultivating Engineering Practice Ability and Innovative Thinking

The practice-teaching system for vocational communication programmes is now far from meeting the demands of industry and national

defence, and it fails to promote the development of engineering practice ability and innovative thinking.

2.1 Practice Scenarios are fixed, and Ability Training is cut off from Operational Needs

The practice teaching in these programs mainly uses confirmatory experiments and standardised drills, has a limited scope, and is far from the complexity of real work. Most of the on-campus experiments are based on the course knowledge points, such as high-frequency electronic circuits and communication theory, and students only need to follow the steps to modify equipment or detect signals. electromagnetic interference, equipment failure and multi-site coordination are not covered by the above designs. Therefore, students are not often exposed to unforeseen problems in their work, and their engineering practice ability remains at the level of operating skills rather than reaching that of problem-solving. School-enterprise cooperation is also relatively shallow and generally limited to internship placement and order-based training. Enterprises are concerned about production safety and efficiency, so they rarely have students participate in scheme design or fault handling for key communication projects; thus, no real projects exist for students to practise solving complex engineering problems [2].

2.2 Instruction Runs One Way, and there is No Vehicle for Innovative Thinking

Teaching is still in the old mode; it is teacher-led instruction, student memorisation and experiment verification. There are no open-ended questions or areas of conflict in the classroom. Instruction centres on standard answers. Students are used to passively receiving knowledge; they lose the motivation to learn independently or explore what has been taught; thus, the development of innovative thinking is not promoted. The practice session is not for competition, and there exists no intuitive standard to judge whether one scheme outperforms another. Students cannot learn about their own deficiencies through comparison and debriefing, and the sense of innovation that would motivate them to deviate from the norm and improve a plan is difficult to inspire. The graduates of this model are mainly suitable for standardised operating positions and find it difficult to adapt to an industry with rapid technological iteration and shifting demands [3-5].

3. How Wargaming Strengthens Competence in Communication Students

Wargaming is already established in the teaching institutions. It is a simulation that puts the participants in an adversarial situation close to reality, and then in a dynamic competition, makes full-cycle decisions, implements them, and finally debriefs. These characteristics are in line with the demands for cultivation of communication ability [6-8].

3.1 An Analytical Framework: the Experiential Learning Cycle and Situated Cognition

The conditions for the formation of competence are to have an authentic problem situation, opportunities to try out solutions and bear the results, and a reflective period in which the decision can be reviewed. According to Kolb's cycle of experiential learning, for reflection to be effective, the experience should be sufficiently complete [9]. Lave and Wenger's theory of situated cognition is a form of learning through participation in a community of practice; therefore, learners must take a position requiring genuine judgment in order to learn in this way [10]. Conventional practical training only partially satisfies situational authenticity yet falls short in both trial and reflection. Wargaming is relatively low-cost and can fully satisfy all three prerequisites for competence development [11].

3.2 Adversarial Perturbation: Uncertainty Returns to the Engineering Situation

The most fundamental distinction between wargaming and simulation software lies in the adversary. In simulation software, interference is merely a preset parameter. In a wargame, there is a living person who observes and learns from you to change things. Blue observes that Red clusters its critical nodes in one area and adjusts its jamming direction accordingly. When Red needs to use a backup route, Blue will also close that route.

This kind of conflict does not have full awareness. Students no longer have a problem of a known answer; instead, they have been met with disappointment. A few questions that no drill worksheet will ever have. If it is likely that the opponent will use a particular kind of

interference, but the parameters are unknown, how much redundancy is needed? What risks arise from committing all available resources to a single scheme? At what time should the existing deployment be abandoned and a different way of doing things used? None of them are the correct answers, and all of them have costs. All of the students' choices will have an effect in the following rounds: suppressed links, degraded services and wasted time. Engineering judgment is the result of many choices and their corresponding outcomes. Drill tasks cannot provide that texture of experience.

3.3 The Decision-Debrief Loop: Making Innovative Thinking Visible

Innovative thinking cannot be simply lectured to students; it must be made visible. Wargaming offers an artificial environment for the display of thinking. There is no single answer, and the schemes produced by groups in the same situation are quite different. The above differences can be used as the basis for comparison and inquiry. Debriefing is the organisation of interrogation. Red shows the chain of decisions at various times, the information available at each stage, which options were not selected, and why a specific plan was chosen. Blue explains how it identifies Red's vulnerabilities and its intended targeting strategy. The directing group provides quantitative criteria and identifies avoidable losses.

As there is no single answer, a set of organised questions has been developed for the debriefing: Red explains why it was decided to go that way; Blue describes the planned offence; and the directing group provides quantitative indicators. Students need to put their vague intuitions into words, engage in several rounds of counterfactual thinking, arrive at a loop of problem identification, analysis, and re-imagination of solutions, and view a scheme as a testable hypothesis rather than a fixed task at this time.

Students must translate vague intuitions into explicit verbal statements; a judgement that cannot be clearly articulated cannot withstand scrutiny. Debriefing turns counterfactual speculation about alternative courses of action into a regular practice. Time and again, one is eager to observe a plan rather than to carry out the corresponding operations. This is how innovative thinking develops. It does not arrive in a flash of inspiration. It operates in a continuous loop of problem detection, analysis and remedy design; the purpose of wargaming is to make this cycle visible to the students and, at a higher speed, within the classroom environment.

3.4 Systemic Constraint: Moving Competence from the Equipment Level to the Mission Level

Communication support is never an isolated technical activity. Whether a link can be established depends on the availability of sufficient frequency, power and manpower. Whether it can be continued depends on whether cooperation with other parties has been achieved. Whether establishing a link is worthwhile depends on its contribution to mission objectives.

Wargaming compels students to weigh these interrelated questions together. Present the mission background and the commander's objectives in a scenario, and all schemes should be able to answer the three questions: Who will be helped? To what extent? And at what cost? When students find that covering a secondary direction with all their mobile force has left the main direction unsupported, the coordinate system for evaluating competence changes from whether the equipment is functioning to whether the mission is being achieved. That change is the transfer of ability. Equipment-level competence addresses how to use the equipment correctly; Mission-level competence focuses on how to deploy resources to achieve mission effects. The first can be trained through drills. The second can only be cultivated under mission pressure.

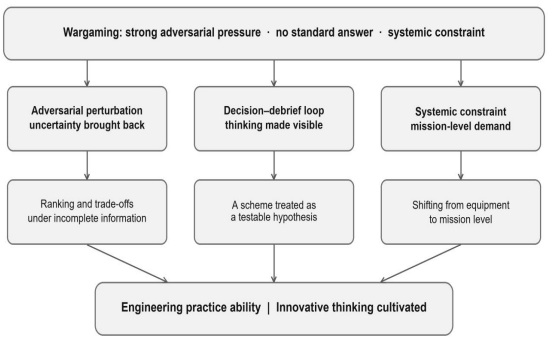


Figure 1. Mechanisms through Which Wargaming Supports Competence Development in Vocational Communication Students

There is a particular boundary condition, however. The strength of the systemic constraint

must match the resource-scheduling experience students already have. If scenario resource constraints exceed students' reasoning capacity, learners will merely attribute failure to resource shortages rather than learning to make rational trade-offs. Therefore, the design of the resource ratio in a scenario should not be too high; it should be in a range that students can achieve themselves through their own efforts. Figure 1 shows how the three mechanisms above are used to achieve ability goals.

4. An Implementation Pathway for Wargaming Teaching in Vocational Communication Education

The two ways need to satisfy the conditions. It needs to be in line with the capability structure of communication majors, and it must be feasible given the current faculty and funding situation. The four are: Task system, teaching organisation, Assessment design and support mechanism.

4.1 A Three-Tier Task System: Adapting Rules and Building a Scenario Library

Off-the-shelf wargames are poorly suited for communication classroom teaching. Military wargames determine the outcome of a battle through attrition and territory gained or lost, and communication support is represented merely as an abstract capability value. To train communication ability, the rules of a war game need to be modified.

Rule adaptation abstracts communication support into a set of quantifiable metrics for adjudication. Set the parameters of the equipment in the rules, such as communication range, bandwidth, anti-jamming capabilities, power consumption, setup and teardown time, and sensitivity to terrain and weather. The library does not need to be large, but it must be hierarchically organised, such as link availability, end-to-end delay, coverage, anti-jamming margin and recovery time after an outage. Only after both steps are completed will the student schemes have an objective basis for comparison, and only then can debriefing avoid being a collection of random opinions.

Scenario library development runs alongside. A small library is fine; the problem is a lack of organisation. The three types of training complexity are: basic, integrated, and mission-oriented. Basic scenarios cover single-station networking and link restoration and fit within regular class hours. Integrated scenarios incorporate multi-station networking and contention for frequency, power and manpower to create an effective training week. A mission-level scenario will restore the communication support to full operating capacity, and students will need to design and justify an entire support system; it is suitable for a semester project or competition training.

4.2 Four-Stage Teaching Organisation: from Asking for Steps to Asking for Conditions

What is required of the teaching organization is not a certain procedure, but whether the nature of student activity changes at different times. Table 1 shows the basic operations and the corresponding changes in teacher roles.

Table 1. Key Actions and Teacher Roles across the Four Stages of Teaching Organisation

Stage	Main student activities	Teacher role	Main evidence produced
Theory study (pre-class)	Study the wargame rules and equipment parameters; complete a preliminary scheme design	Scenario issuer; resource provider	Preliminary scheme; parameter calculation sheet
Adversarial play (in class)	Red-Blue confrontation; respond to directing events; report decisions	Director; adjudicator	Wargame log; decision report
Debriefing seminar (post-class)	Present the decision chain; respond to challenges; compare the two sides' schemes	Interrogator; attribution guide	Debriefing report; revised scheme
Transfer to practice	Cross-check the wargame conclusions against real cases and practical training tasks	Resource linker; assessor	Transfer task output

The pre-class stage is not for previewing textbook knowledge points. Its core task is to generate a preliminary scheme for subsequent validation. The teacher presents the scenario background and rules, and the students need to find equipment parameters and perform an initial calculation of forces and resources independently. Therefore, knowledge acquisition is embedded within a concrete problem: students study actively to answer the posed question, which greatly improves learning efficiency.

The stage of the class is a Red-Blue conflict. Red Designs and executes the communication

support scheme. Blue acts as the jammer and saboteur and introduces dynamic requirement changes. The directing group is jointly led by the teacher and trained senior students, and a set of pre-designed event cards are used to set rules or choose for the events. The node is in electromagnetic suppression; the route has been physically cut; the backup power has 2 hours left; and higher headquarters has temporarily increased the support level in that direction. The tempo of play must be managed. Play too many cards and the exercise becomes a game of reacting to random events; play too few and there is no pressure.

The three-way post-class debriefing is the most vulnerable segment of the entire teaching chain. Effective debriefing focuses on tracing the decision chain rather than merely exchanging subjective impressions. Red can be asked to list the reasons for its decisions in chronological order; Blue can explain why it thinks there are deficiencies in Red, and the directing group should use objective indicators to specify the preventable damages.

A Transfer-to-Practice stage is often omitted, and thus wargame experience fails to be applied in practice. This step verifies whether key conclusions drawn from wargaming align with real-world conditions. Can the redundancy strategy in the game actually be implemented for real equipment? How far is the set-up time assumed in the game from the time actually taken in the workshop? This validates the credibility of the wargame while reconnecting students with physical equipment.

4.3 Performance Assessment: Bringing Process Evidence into Evaluation

Assessment reform needs to make the process transparent here. Wargaming teaching generates abundant process evidence, including decision reports, wargame timelines, communication logs, debriefing statements and revised schemes. containing decision records, wargame schedules, communication logs, debriefing statements and revised plans. If only that evidence is filed and never considered, then evaluation reverts to judging performance solely by victory or defeat.

Performance evaluation: A five-dimensional performance rubric is adopted, covering scheme soundness, decision-making efficiency, adaptability and innovation, coordination and expression, and debriefing depth. The highest weights are assigned to scheme soundness and adaptability and innovation. The first is a measure of the strength of engineering thinking; the second shows observable behaviour of innovative thinking. Winning or losing should not constitute the primary scoring criterion. Victory is also affected by contingent factors, such as the situation of the circumstances and the distance between the strengths of the two teams; if this becomes the main focus of evaluation, the classroom may be led to gamesmanship. Initial rubric versions should avoid excessive granularity. Too many items increase the teachers' workload and encourage students to pursue individual checklist items merely to gain points. A safer way is to pilot the rubric in the practical training part of a few courses, build a sample of evidence, and only then adjust the descriptive levels.

4.4 A Civil-Military Mechanism for Resources and Faculty Support

Resources and faculty provide the basis for all other aspects, and without them, wargaming education cannot proceed. The starting point of resources can be very low. Tabletop wargaming has near-zero marginal cost; a class can be run using only maps, counters and a scenario booklet, making it an ideal testbed for rule adaptation. Once rules and scenarios are stabilised, a computerised wargame system can be introduced and further developed. With communication equipment parameter settings, electromagnetic environment models, and spectrum management rules. Institutions with the necessary funds can establish wargaming laboratories in cooperation with military academies, service communication units or communication enterprises, and share training and project cases.

Faculty shortages are relatively more severe than equipment shortages. Wargaming changes the expectations of teachers; now they need to be able to design a scenario, lead the rhythm of play, and pose probing questions during the debrief. Traditional teacher training covers none of the above. A practical response is to hold scenario design workshops, have teachers develop scenarios and event cards together, and then try them out on one another to gradually build a school-based resource pack. Communication specialists from the services and technical experts from enterprises can also be engaged as part-time directors, which offsets the faculty's limited operational experience.

5. Conclusion

Wargaming opens a new entry point for practice-oriented reform in vocational communication education. It has a high-fidelity and strong adversarial property, can break out of the rigidity of traditional scenarios and the weakness of innovation training, and simultaneously enhance engineering practice ability and innovative thinking. As intelligent simulation, digital twin and related technologies mature, wargame systems will be further upgraded. to build close-to-reality communication support scenarios and provide stronger support for the training of communication talents. In the future, research can be conducted on how to integrate wargaming with artificial intelligence to develop a series of wargame modules for various communication sub-fields, thus promoting the normalisation and standardisation of wargaming within communication education and providing more high-quality technical and skilled talent for industry and national defense.

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