Distance learning in advanced military education: Analysis of joint operations course in the Taiwan military

Ming-Chih Tung a, Jiung-yao Huang b,∗, Huan-Chao Ke c, Shu-shen Wai c

a Department of Computer Science and Information Engineering, Ching Yun University, 229 Chien-Hsin Road, Jung-Li, Taoyuan County 320, Taiwan
b Department of Computer Science and Information Engineering, National Taipei University, 151, University Road, San Shin, Taipei 237, Taiwan
c Department of Computer Science and Information Engineering, Tamkang University, 151 Ying-chuan Road, Tamsui, Taipei County 251, Taiwan

ARTICLE INFO

Article history:
Received 21 November 2008
Received in revised form 3 April 2009
Accepted 5 April 2009

Keywords:
Applications in subject areas
Architectures for educational technology system
Distributed learning environments

ABSTRACT

High-ranking officers require advanced military education in war tactics for future combat. However, line officers rarely have time to take such courses on campus. The conventional solution to this problem used to take the inefficient correspondence courses. Whereas Internet technologies progress, online course is the current trend for military training. However, the question is what distance learning methodology best suits such a proprietary learning purpose.

This study presents a sequential process of developing distance learning courses in advanced military education. Further, the Petri-Net analytical approach is adopted to discover the essential interaction requirements of advanced military education delivered via Internet. This study developed a systematic method for designing e-learning systems according to specific requirements of target courses. The proposed approach starts by comparing on-campus programs with the existing e-learning systems to identify the steps required to transform the program into an e-learning system. After first outlining the pedagogy of the on-campus program, its proposed teaching flow through the Internet is then sketched. Finally, the Petri-Net model was used for in-depth analysis of the stages affecting the learning curve of the line office taking e-learning courses. The example of a “Joint Operations” AME course elaborated the presented approach. An e-learning system prototype was also designed accordingly. Lastly, an experiment was conducted to verify the efficiency of the presented approach.

Crown Copyright © 2009 Published by Elsevier Ltd. All rights reserved.

1. Introduction

Military education focuses on training students in specialized engagement skills needed in future combat. The fundamental differences between civilian and military education are their goals, motivations and targeted applications. In traditional civilian education, achievement is measured by the knowledge acquired from a lecture program. Hence, the extent of educational achievement is generally open-ended. The goal of military education, however, is to prepare military personnel for specialized functions and tasks (Department of Army, 2003). Moreover, in military education systems, learning is measured by mastery of predetermined doctrines and criteria. The goal of military education is to transform a student officer from a novice into a military specialist. Once the initial level of proficiency is achieved, an officer can continue his education with actual working experience in his post.

Military education includes training programs ranging from the basic curriculum, in-service education, to the advanced education. After completing the basic curriculum, military officers must receive short-term specialized trainings in different military-branch schools including the infantry, armor and artillery branch schools of the Army, etc. Further, candidates for promotion to colonel and major general must first undergo advanced military education (AME) training (Taiwan Yearbook, 2007). The goal of the AME program is to educate commanding officers in the tactics required for joint combat operations. In this study, personnel receiving AME training are referred to as “officer students”.

Due to their work responsibilities, line officers rarely have time to leave their posts to take AME courses in a traditional college campus. To solve this dilemma, the correspondence curriculum for AME is now offered as an alternative. In this program, officer students study course materials and complete their assignments in their leisure time. The learning progress of the students is reported to their instructors.
2. Related developments

2.1. E-learning in military education

There are a lot of military education systems and researches, but studies of distance learning for advanced military education are rare. In 1997, the US GAO conducted a study to estimate the cost of providing distance learning education in the Department of Defense (US Government Accountability Office, 1997). The results of the estimation study showed that the primary payoff would be the reduced number of days that military personnel would be away from their units. A subsequent GAO (US Government Accountability Office, 2004) study in 2004 analyzed the effectiveness of distance learning for AME in military personnel, most of whom were senior-level officers. The purpose of the study was to determine, from the perspective of the officers, how the AME program impacted their careers and fulfilled the learning objectives, obstacles and challenges of e-learning based on AME. The study showed that the military must scheme the learning objectives of its e-learning courses for the AME program. Clear learning objectives simplify the development of e-learning systems.

During monthly faculty meetings. For AME courses such as “National Security” and “War Theory” which do not demand interaction, this method of self-learning is effective. However, this asynchronous teaching method may be ineffective in courses such as “Joint Operations”, which require more frequent interaction among officer students. To correct the deficiencies of such a correspondence program, e-learning via Internet may also meet the requirements of on-campus education while still preserving the virtues of correspondence courses.

Distance learning and e-learning systems for military education have become common in recent years due to the growing need to train line officers for rapidly changing international conflict scenarios (TRADOC, 2001). Combining e-learning with computer-based training has been proven effective for improving line officer combat skills (Roffe, 2002; Schechter, Bessemer, & Kolosh, 1992; Urdan & Weggen, 2000). Key studies of distance learning applications in military education were performed by Bonk and Wisher (2000) and DUSD (1999) of US DoD. These reports advocate the use of on-line learning systems to improve the efficiency of military education. Recently, the integration of e-learning techniques with the on-campus AME program has been further examined (Sentz, 2006; US Government Accountability Office, 2004). Although the military has extensively used e-learning technology to train line officers, a continuing question is what e-learning modules should be developed to achieve the same learning performance as the on-campus program. The essential problem of these questions is that the learning objectives and activities of on-campus AME aim to develop cooperation and brainstorming skills. This study presents a systematic means of assessing the required crucial e-learning modules when transforming an on-campus AME course into an equivalent e-learning course. Further, the presented approach was successfully applied to develop an AME course prototype in Taiwan.

To elucidate the difficulties of designing an e-learning system for AME, Table 1 shows the relation between the legacy e-learning education and the on-campus AME program. In the legacy e-learning education system, students need only study materials and exercise the course assignments provided by their teachers. Further, its course design emphasizes an asynchronous mode of self-study with a knowledge management/performance support system. The AME program, however, requires instructor–student interaction as well as group discussions among students. The core curriculum of the AME program includes leadership and management theory, military history and operational doctrine, national defense policy, war operation planning and decision-making, legal responsibilities, professional ethics, etc. The AME program can be characterized as performance-oriented. Student performance is evaluated by their battle plans for the assigned missions and reactions to the simulated military conflicts. Through repeated course discussions and regular performance evaluation, officer students are expected to become skilled commanders in future warfare.

Since line officers (i.e., candidates of colonels or major generals) often have a great difficulty leaving their posts for on-campus programs, correspondence courses in the AME program are required to train line officers. Further, as computing and Internet technologies evolve, the e-learning approach can effectively provide distance learning by correspondence education with the same learning efficiency as on-campus programs. However, few studies have proposed systematic ways to develop e-learning courses based upon the specific needs of the AME program (Sentz, 2006). The following sections first discuss the drawbacks of correspondence courses. The Petri-Net method is then analyzed to clarify the procedure for developing AME e-learning courses. Finally, a prototype AME e-learning course developed by use of the presented approach is presented.

Table 1
The relation between advanced military education and legacy e-learning education.

<table>
<thead>
<tr>
<th>Legacy e-learning education (including military fundamental education &amp; enterprises in-service/on-job training)</th>
<th>On-campus advanced military education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendants</td>
<td>Candidates of colonels or major generals (or equivalent ranks in the Navy)</td>
</tr>
<tr>
<td>Learning mechanisms</td>
<td>The course design is based on the joint operation procedure. The course is held with intense discussion assisted by the instructor to cultivate officer students’ conception of joint operations. In this course, after given specific parameters and assumptions, officer students are also asked to design appropriate battle plans and to set up different joint operation scenarios. Once these battle plans are made, simulations are then conducted to test the feasibility of these plans. Through these exercises, officer students are trained to react to a variety of operational situations with precise decision on the spot.</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>This level of education aims to develop officer students’ leadership skills in commanding, research, and defense resource management</td>
</tr>
<tr>
<td>Course contents</td>
<td>War theories, principles, and management knowledge, combining with simulation technologies to help commanding officers make decisions on the spot.</td>
</tr>
<tr>
<td>Instruction</td>
<td>Regular group meetings or after-action review meetings</td>
</tr>
</tbody>
</table>
Although several countries now use e-learning systems extensively to train their military personnel, a continuing question is how much e-learning would transform and which e-learning courses can replace on-campus military ones. The AME learning objective is to train officer students to make complex strategic decisions. Whether on-campus AME courses can be delivered effectively in a distance learning environment is uncertain. Distance education has been proven to be an effective medium for experimental learning, problem solving and leadership exercises, which are the core subjects in most military e-learning programs. Research shows that the following factors are essential for effective e-learning for advanced military education (Wisher, Sabol, et al., 2002):

- classroom participation;
- application knowledge related to real-world scenarios;
- strategies for increasing the likelihood of student success and for helping students see the immediate value of what has been taught.

To address the above issues, military e-learning systems must be designed carefully. The AME primary concern should be the development of instructional strategies that most effectively capitalize on the power of new scheme for planning e-learning courses. Conversion of training from traditional correspondence and campus learning to those which are technology-based involves more than just the downloading of lecture notes and briefing slides. Trying to mimic the traditional learning method through the use of advanced technologies is a dis-service to the power of those technologies and the students who are trying to learn through them. Instructional strategies need to be rethought by the proper approach so that interaction can be maximized to keep students attention and motivation maintained. This study analyzed the development process for e-learning courses in the AME program. This study started by comparing correspondence learning, on-campus education and e-learning. After identifying these differences, the e-learning modules of AME e-learning courses were analyzed to determine which were essential. This process improved the design of the e-learning system and minimized the drawbacks of correspondence courses so that their effectiveness could be comparable to traditional on-campus courses.

2.2. Comparison of on-campus programs, correspondence courses and e-learning

Some researchers differentiate distance learning from the broader concept of e-learning. In essence, e-learning employs many new training technologies such as web-based training and computer-mediated communication (Hall, 1997; Roffe, 2002). Comparisons of on-campus and e-learning programs reveal the following differences (Sanders & Burnside, 2001):

- Need to designate specific class time and locations: E-learning can be done anytime and anywhere whereas on-campus programs require specific time and locations.
- Multimedia content: E-learning integrates various multimedia, including audio, animation, video, simulation, online resources and communities into a unified display interface; however, traditional classes often rely on slide presentations, textbooks and videos.
- Personalization: E-learning allows the user to set the learning pace and path whereas the teacher in a traditional classroom guides the learning pace and path for all students.

Previous studies of e-learning effectiveness indicate that e-learning courses can be as effective as on-campus programs (Allen, Bourhiis, Burrell, & Mabry, 2002; Bernard et al., 2004; Cavanaugh, 2001; Machtmes & Asher, 2000; Mayzer & Dejong, 2003; Murphy, 2000; Ramage, 2002). One frequently cited study by Russell (1999) who analyzed 355 learning programs, including correspondence, on-campus and Web-based courses taken by students at all levels of academic performance. After compiling the results of numerous studies, he concluded that 90% of the studies showed that, in terms of student achievement, distance learning and on-campus programs did not significantly differ.

Studies by Sanders and Burnside (2001) showed that students can be trained faster in e-learning courses than in correspondence ones. Further, surveys and interviews with students and instructors in e-learning courses indicate that they are generally more positive about e-learning courses than about paper-based correspondence ones. This study also disclosed some novel findings about e-learning courses. In fact, surveys of small-group instructors also indicate that students taught via e-learning programs are more confident in making decisions and develop a better sense of team identity than students in correspondence courses. Additionally, students who have taken e-learning courses demonstrate better planning skills, confidence, tactical proficiency, leadership and supervisory skills.

Attrition, which is measured by the dropout rate or non-completion rate, is a common problem in distance learning programs (Berge & Huang, 2004; Henke & Russum, 2000; Morgan & Tam, 1999; Rossett & Schafer, 2003). The key difference between military and nonmilitary courses is that military students must complete specific courses if they expect to be promoted. Since promotion is a key incentive for military students to take the courses, they are sufficiently motivated to complete their courses. That is, the candidates of colonel and major general must first pass AME program if they expect to be promoted; therefore, this study will ignore the dropout issue in AME program. Given the difficulty for officer students to join on-campus programs, AME courses are the most suitable for delivery via e-learning technology.

3. Distance learning for advanced military education

3.1. AME in Taiwan

The AME teaching objectives differ from those of academic courses. The AME focuses on specific skills training whereas academic education concentrates on knowledge tuition. In recent years, the Taiwan military has demonstrated its commitment to using distance learning technology for training and educating geographically distributed line officers. Given the growing complexity of military technologies, the need for continuous technical training has also been increased. The cost of money and manpower to dispatch line officers to distant facilities for on-campus training is often unacceptable. As mentioned above, correspondence courses are currently the only alternative to campus programs. To minimize the cost of advanced military education, this study performed an in-depth analysis of a systematic procedure for designing e-learning modules in AME courses.
The AME curriculum in Taiwan includes two course types, basic tactics courses and advanced strategy courses. These courses provide officer students with advanced leadership skills ranging from planning combat missions to managing supplies, maintenance and information assets in a complex organization. The basic tactics courses introduce operational concepts but primarily focus on tactics at the Division level whereas advanced strategy courses concentrate on national security policy-making and war strategies. Further, the advanced strategy courses are intended to develop student officer leadership in command, research and military supply management. Candidates for colonel or major general in Taiwan are required to complete AME courses before advancement (Taiwan Yearbook, 2007).

The core curriculum of AME focuses on “Military Force Construction” and provides supplementary courses in war readiness. The AME subjects include “National Security”, “Enemy Research”, “International Relations”, “War Theory”, “National Defense Decision Making and Management” and “Joint Operations”. These courses train officer students in joint operations and field exercises. Upon completing these courses, these officer students are expected to become master architects of future force structures and combat operations.

Among these courses, the “Joint Operations” course is a practical training that focuses on tight interactions and communications among officer students. This course requires officer students to cooperate in repeated war game simulations until they become experts in commanding and dispatching troops for joint operations. The learning effectiveness of this course depends on whether it is delivered on-campus or through correspondence programs. The on-campus program offers officer students the opportunity to work as a team and to demonstrate what they have learned collaboratively. Fig. 1 shows a detailed flowchart of the on-campus “Joint Operations” course. Conversely, officer students in correspondence courses can only complete theoretical and doctrinal courses individually without opportunities to experience live team operations.

The differences between the on-campus and correspondence programs for “Joint Operations” are listed as following:

- **Learning style:** The on-campus course teaches joint operations through interactive war games whereas students in the correspondence program write reports rather than participate in activities. The “Joint Operations” course aims to help officer students acquire in-depth understanding and skills in managing military missions for joint operations. Firepower management and response to contingency conditions are two core concepts in this course. Both capabilities are developed by focusing on coordination and interaction among commanding chains. In contrast with the on-campus courses, the correspondence courses only require officer students to submit written reports to their instructors.

- **Learning effectiveness:** The interactive games in the “Joint Operations” course are followed by on-campus discussion and review. However, in the correspondence program, instructors and officer students communicate mostly by e-mail. Therefore, after-action review discussion is difficult in the correspondence course. Both capabilities are developed by focusing on coordination and interaction among commanding chains. In contrast with the on-campus courses, the correspondence courses only require officer students to submit written reports to their instructors.

- **Learning participation:** In the war games exercises for the on-campus program, the instructor plays the role of director. Meanwhile, officer students must select from the various commander and staff member roles to participate actively in this interactive war game. However, since the officer students in the correspondence program have insufficient time to attend school, interactive war game exercises seem impossible.

- **Learning materials:** The scenarios for the courses are quite different. The training content for the on-campus course is based on interactive war games whereas the correspondence courses only introduce a decision support model without any actual case studies.

The differences and gaps between the on-campus program and the correspondence program in the “Joint Operations” course clearly indicate that the correspondence program is less efficient. To overcome this problem, this study presents an e-learning system for advanced military education: Distance Learning for Advanced Military Education (DL4AME). The Distance Learning for Advanced Military Education system uses analytical simulation models for the “Joint Operations” course which is the core AME course. The analytical model offered by
DL4AME provides accessible joint operations scenarios and situation management services. Further, the DL4AME system uses videoconferencing to facilitate after-action review discussions between the instructor and officer students.

3.2. Requirements analysis

As discussed above, the “Joint Operations” course is the core course of the advanced military education program; the others are delivered in lecture format. Therefore, the rest of this paper focuses on the “Joint Operations” course to explain the process for designing the DL4AME system.

Fig. 1 shows the pedagogy of the “Joint Operations” course. Two major activities are cooperation in war game simulations and group discussion in after-action review meetings. Both activities are easily performed in the on-campus course. However, due to the varying duty requirements of the officer students, a meeting of all students, even by teleconferencing, is extremely difficult to arrange. To solve this problem without compromising the learning efficiency obtained by cooperation and communication, analytical simulation models along with video conferencing systems are adopted for DL4AME. Fig. 2 gives the teaching flow for the “Joint Operations” course delivered by Internet.

As Fig. 2 shows that, as in the on-campus program, the instructor can plan war game exercises and assign missions to individual officer students. Officer students at the remote sites can then start scenario development and operations planning through the DL4AME interface. For each case study, each officer student can choose an appropriate DL4AME model. The scenario setting follows the operation plan developed by the officer student. According to GIGO theory (Bininda-Emonds, 2004), this is a key step in running an analytical model. After performing the simulation, each officer student may check the simulation results by comparing it with their tactical judgments. If the simulation results show that their tactics or logic are incorrect, the officer students may revise some parameters and repeat the simulation with a new setup until they are satisfied with the results. Officer students can then write their reports according to the simulation results. A video conference among officer students and the instructor is held after all students have submitted their reports. Thus, the virtues of asynchronous learning provided by distance learning technology can be realized without compromising the interactivity needed for the “Joint Operations” course.

3.3. Functional analysis by Petri-Net model

After defining the functional requirements of the “Joint Operations” course in DL4AME, the Petri-Net model is then employed to systematically investigate the learning flow in detail. Based upon the analytical results, the essential e-learning modules for the “Joint Operations” course are then easily identified.

The Petri-Net is a graphical and mathematical modeling tool for the description and analysis of concurrent processes which arise in systems with many components (distributed systems) (Petri & Reisig, 2008). With its intuition, visibility and many fine mathematical properties, Petri Net has been widely applied to fields such as distributed systems, information systems, and discrete event systems and so on. E-learning system is composed of instructor component, student components, e-learning servers, video conference system, email system, etc. This is a distributed architecture that all components are connected with network. With the help of the netted representation by Petri-Net, the researcher can easily discover the potential problems of a running system and then adjust the design to e-learning system validity.

A Petri-Net model can be formally denoted by 3-tuple, PN = (P, T, F) where (Huang & Deng, 2000; Peterson, 1981):

- P = { p₁, p₂, …, pₘ } is a finite set of places.
- T = { t₁, t₂, …, tₙ } is a finite set of transitions. Most importantly, P and T must satisfy the properties of P ∩ T =  and P ∪ T ≠ . Restated, at least one of these two sets P and T must not be empty.
$F \subseteq (P \times T) \cup (T \times P)$ is a set of arcs (flow relation) between network places and transitions. The $(P \times T)$ represents the set of arcs that flow from places to transitions. The $(T \times P)$ is the set of arcs flowing in opposite directions.

According to the definition of Petri-Net, this study defines each place $P$ as a learning step or data repository of the “Joint Operations” course and defines each transition $T$ as its actual teaching/learning stage. Hence, Fig. 3 shows the teaching flow of the “Joint Operations” course for the on-campus program as captured by the Petri-Net model.

Given the nature of the “Joint Operations” course, Fig. 3 divides the learning flow of the course into three layers: the instructor, the war game system, and the officer students. The course starts from place $P_0$, i.e., the preparation step of the instructor layer. The instructor begins by developing a war game plan at $T_1$ to guide the progress of the upcoming joint operation. The material of the plan includes the goals and duration of the war game, the arrangement of the participants and their roles, the exercise space, the firepower, the force structure, etc. When the exercise is planned at $P_1$, the instructor then assigns missions to the officer students, depending on their respective roles, on $T_2$. Upon receiving the mission assignment and a specific operation request at place $P_2.2$, an officer student then develops an assumption and operation plan based on the assigned role on $T_4$. The student then proceeds to stage $T_5$ to set the war game system with the assumptions and related parameters.

Meanwhile, the instructor at $P_2.1$ continues to $T_3$ to prepare the war game simulation for the course. The preparation is intended to divide the war game exercise into several phases and to develop a detailed plan for each phase so that the officer student can use the plan as a reference during the exercise. When the instructor and student officers reach place $P_3.1$ and place $5.1$, respectively, they meet at $T_6$ to determine whether the war game system has already been set up according to predefined war game objectives. After the preparation at $P_6$ is completed and confirmed, the joint operation war game exercise is then launched on $T_7$. During the exercise, the instructor can patch some extemporaneous cases through $T_9$ to the ongoing exercise to increase the realism of the exercise. At the same time, officer students can promptly deploy their forces to practice their decision making ability on $T_8$. When the exercise ends at $P_7$, each officer student must first submit a report on $T_{10}$. An after-action review meeting is then held by the instructor on $T_{11}$ so that each officer student can present what was learned from the exercise. In the review meeting, officer students can exchange thoughts to reinforce their learning effectiveness.

Fig. 3. The Petri-Net model of the “Joint Operation” course for on-campus program.

Fig. 4. The Petri-Net model of the “Joint Operation” course for DL4AME.
Similarly, the Petri-Net model of the “Joint Operations” course for DL4AME, as depicted in Fig. 4, can also be derived from Fig. 2. As in Fig. 3, the instructor starts from learning stages T0 and T1 to develop a war game plan and assign a mission to each officer student. However, the difference is that the instructor needs not prepare the war game simulation for the course. Instead, upon receiving the assigned mission and operation request, the officer students begin developing their own assumptions and operations planning in stage T3. After completing the assumption development, the officer student then selects a war game model from the T4 repository. After an appropriate model is selected, this model then becomes the basis for the analytical simulation in stage T5 according to the assigned mission. An analytical simulation is then repeatedly executed on stage T6. After each simulation, the simulation results are checked with the mission assignment on stage T7. If the results do not meet the mission requirements, the officer student must repeat the simulation by resetting the simulation parameters on T5. If the simulation results meet the goal of the assignment, the officer student then begins to compose his final report in stage T8 and submits it to the instructor. After the instructor receives reports from each student and comments on all of them in stage T9, he contacts each officer student by email to arrange an online meeting. This Internet meeting can be held through any audio/video conferencing system such as Skype, MSN or any proprietary video conferencing system. This discussion stage in T10 is the same as the after-action review meeting in which students share their experiences and enhance their learning achievements accordingly.

3.4. The Petri-Net model for DL4AME

Fig. 4 shows that the flow of the “Joint Operations” course can be divided into five phases: Exercise Planning, Mission Planning, Simulation Setting, Simulation Execution and Discussion. This study must further explore each phase to identify the e-learning modules needed to support the online “Joint Operations” course.

The Exercise Planning phase includes stages T1 and T2. In this phase, the instructor plans the war game exercise for the course and assigns missions to each officer student. This phase is performed at the discretion of the instructor. The system only provides a user-friendly interface for the instructor to input his exercise plan and to assign missions to each officer student.

The Mission Planning phase includes only stage T3. After receiving the assigned mission and role from the instructor, the officer students must develop their own assumptions and plan their operation steps for the assignment. In the on-campus program, officer students can easily receive assistance from the instructor or classmates. In a distance learning format, however, getting assistance from others is difficult during this phase. To ease the learning curve of the officer student, the system should enable students to consult stored assumptions of their senior classmates. Hence, Fig. 5 shows a different model of stage T3.

During stage T3, the officer student must first select a theme for the simulation. After selecting a theme, the student then begins to develop assumptions through the Assumption Management Interface P3.1.1. Meanwhile, the student can access the assumptions of senior classmates from the Assumption Database P3.1.2. Similarly, the officer student can consult Doctrine Database P3.2.1, and Operation Plan Database P3.2.3 when developing an operation plan from the Operation-planning management interface P3.2.2.

The Simulation Setting phase includes Model selection stage T4 and Scenario setup stage T5. After the officer student develops an assumption and operation plan, the student must then select a model and set the simulation parameters for the subsequent analytical simulation. Since the distance learning approach precludes consultation, the system should provide officer students with a database of examples. Hence, Fig. 6 shows a proposed expansion of the Simulation Setting phase.

The Model repository provided by the system enables officer students to select and modify existing models from repository P4.3 during Model selection in stage T4. Likewise, the officer student can consult Parameter database P4.1 and Scenario database P4.3 when setting the simulation system parameters for stage T5.

The Simulation Execution phase includes Run Analytical Model Stage T6 and Simulation Check Stage T7. Since these two stages only require the officer students to follow their preset models and parameters to perform the simulation, the two stages have already precisely captured the necessary actions. Therefore, no further extension is required for this phase.

In the Discussion phase, officer students share what they have learned. In the on-campus “Joint Operation” course, the after-action review meeting is a crucial step for achieving the intended learning efficiency. Different Internet technologies for interaction among networked clients must be fully employed when such a meeting is supported by Internet. Hence, Fig. 7 shows a further model of the discussion phase. Among the existing Internet communication technologies, the E-mail system P9.3 is the most common tool for asynchronous communication between instructor and officer students. Additionally, the video conference system P9.1 is an essential tool for en-
abling these group meetings. The electronic interactive whiteboard system P9.2 is another useful tool for pictorial communication during group meetings.

Hence, Fig. 8 shows the results of integrating the concepts depicted in Figs. 5–7 into Fig. 4. It sketches the complete Petri-Net model for the “Joint Operations” course when delivered by distance learning approach.

3.5. The DL4AME architecture

According to the analysis by the Petri-Net model shown in Fig. 8, three essential components of the “Joint Operation” course are realized by Internet. The first part is the user interface that is customized for the officer students according to their input. The second part is a database set of teaching and training materials such as models, results and simulation settings used in previous sessions. The third is a collection of agents that mediate data between user interface and database. Hence, as Fig. 9 shows, the DL4AME has a three-tier architecture that includes: Front-End Web Tier, Application Tier and Database Tier. The Front-End Web Tier contains various user interfaces. The Application Tier is the core of the DL4AME system and consists of all course administrative tasks such as parameter update/query, database update, assumption development, scenario setting, etc. Finally, the Database Tier is a set of database servers that are specifically designed for the advanced military education program. This tier stores data for doctrines, assumptions, scenarios, parameters, models, etc.

4. Implementation and experiments

Two general approaches to design an e-learning system are to design from scratch or to modify an existing commercial product. Both approaches have pros and cons. This research uses the latter approach to develop a prototype DL4AME system. The software package selected for prototyping is the Microsoft Learning Gateway (MLG) (Microsoft, 2007) software package, which is an e-learning platform first released by Microsoft Corp. in 2003. Its main function is to integrate existing Microsoft software tools into an unified system so that students, educators and lifelong learners can teach and learn effectively. The second edition of Microsoft Learning Gateway was later released in 2007 along with Microsoft Office SharePoint Server 2007.
Fig. 8. The Petri-Net model for the “Joint Operation” course of DL4AME.

Fig. 9. The architecture of DL4AME for the “Joint Operation” course.
The MLG is composed of Microsoft Corp. products such as Windows Server, Active Directory, SQL Server, Exchange Server, Office Communication Server and SharePoint Learning Kit. Among them, Microsoft SharePoint Server (MOSS) is the main application for delivering user content through the Web. Additionally, MLG can deliver existing enterprise applications and resources via secure, customized personal web portals. Due to its functional integrity and flexibility, MLG was selected to implement the DL4AME prototype in Fig. 10. The following subsections describe the detailed implementation of DL4AME as well as the experimental verification of the learning efficiency achieved by DL4AME.

4.1. Implementation of DL4AME

Fig. 10 shows that the Front-End Web tier is the user web browser for connecting to the Web part module on the server side. The Web part module is the interface module of the Application tier that serves all AME courses. The Application tier then accesses course materials through the Virtual Path Provider, which is a virtual file system that manages all files and directories within various databases in the Database tier. Additionally, the DL4AME includes a Communication Server and Exchange Server to support on-line discussion and instruction. Since the Application tier is the core DL4AME system, the implementation of this tier is further discussed below.

The Application tier is built on Microsoft Office SharePoint Server (MOSS) 2007, Windows SharePoint Service (WSS) 3.0, and SharePoint Learning Kit (SLK), Enterprise Content Management (ECM), Excel Calculation Services (ECS), Parameter management, Assumption management, Operation-planning management, Model management and Virtual Path Provider. Of these modules, Parameter management, Assumption management, Operation-planning management and Model management are specially designed for DL4AME. Briefly, the function of each component is stated as following:

1. **Web part**: Web parts are pre-designed and pre-defined functional web modules provided by MLG. These modules enable users to customize webpage layouts by adding, editing and removing modules, and all settings are stored in the user profile on the MOSS server.

2. **Microsoft Office SharePoint Server (MOSS) 2007**: This integrated suite of applications includes Portal Features and Search Services, Web Content Management, Business Intelligence, Business Process Management and Enterprise Content Management (Ryan & von Tschudi-Sutton, 2006). It provides a single platform for helping users to manage all web applications in DL4AME architecture. The MOSS 2007 easily provides diverse learning materials such as training content and process management.

3. **Windows SharePoint Service (WSS) 3.0**: This service creates required Website and Web Pages for DL4AME and provides document libraries for storing and sharing learning knowledge among all officer students.

![Fig. 10. The implementation of DL4AME.](image-url)
(4) **SharePoint Learning Kit (SLK):** In the DL4AME system, SLK helps teachers to create assignments from the documents in the SharePoint Document Library. When SLK is integrated with MOSS 2007, SCORM 2004 (Mackenzie, 2004) functionalities are supported so that users can manage their own materials and track documents in SharePoint document libraries.

Notably, the modular architecture of DL4AME enables easy substitution of SharePoint Learning Kit with any other Learning Management System (LMS) for integration with the SharePoint Server. Further, based on the above functional modules (i.e., MOSS, WSS and SLK), Parameter management, Assumption management and Operation-planning management modules can be built accordingly.

(1) **Enterprise Content Management (ECM):** In the DL4AME architecture, ECM refers to technologies used to capture, manage, store, preserve and deliver all course content and documents for running processes. The ECM is further divided into two parts. One is mainly for document management activities such as version control, rights management services, authorization and publishing. The other prints barcode labels for documentation identification, certification and document library maintenance. For example, the content of the Parameter management, Assumption management and Operation-planning management modules can be edited, modified and saved to respective databases through ECM.

(2) **Key Performance Indicator (KPI):** The KPI is traditionally used by trade organizations to analyze business harvests data of an enterprise such as revenue growth and sales forecasts. In the DL4AME system, it is used by instructors to track the learning progress of officer students. These indicators are stored in a list of associated content types. These content types define how KPI is valued. For instance, after an officer student meets or exceeds the learning objectives, a green light is displayed on the instructor part of the web, and a yellow light advises the instructor to focus attention on the student. Finally, the red light identifies students who are performing poorly and must reenroll in the course.

(3) **Excel Calculation Service (ECS):** In ECS, plug-in programs on a browser enable users to load, calculate and render Excel workbooks on the server side. It also provides Excel snapshot file downloads, Excel webpage component analysis and user-defined calculating functions. For example, a web browser can directly trigger spreadsheet model calculation and execution by ECS.

(4) **Virtual Path Provider:** In the DL4AME architecture, Virtual Path Provider enables web applications to retrieve information from the Database tier. That is, Virtual Path Provider constructs a virtual file system for all files and all database directories in the Database tier as an unified database.

(5) **Communication Server and Exchange Server:** The DL4AME integrates communication tools to enable instant messaging capability between officer students and instructor. This function enables immediate sharing ideas and information. Through this communication platform, officer students and the instructor who are geographically separated can communicate without leaving their current posts. Further, an exchange server also provides users with web-enabled mail boxes and personal calendars.

(6) **Model management:** The Model management provides user interfaces for executing simulations. The DL4AME system provides three executable simulation modes. The first is the spreadsheet simulation mode in which officer students can perform spreadsheet simulations constructed by Excel Calculation Service (ECS) through the web browser. The second mode is the standalone simulation mode, which consists of simple warfare simulations such as sub vs. sub tactical model, etc. Officer students can choose the appropriate models to execute and generate results for performance analysis. The last mode is the multi-player interactive simulation mode. In this mode, each officer student can play the role of federation member as specified in High Level Architecture (HLA) (Smith, 1998) in a large-scale war simulation. However, this mode is unsupported in the current research.

(7) **Parameter, Assumption and Operation-planning Management units:** Parameter, Assumption and Operation-planning Management are three customized management units specially designed for DL4AME. Since the goal of AME is to train and develop leadership skills in command, research and military supply management, scenario training and group discussions are the core activities of the entire program. Hence, Parameter, Assumption and Operation-planning management are three important modules in support of those activities. Among these, the major function of the parameter management enables officer students to search and query the Parameter database for needed parameters when setting scenario parameters. Assumption manager and Operations-planning manager allow officer students to develop assumptions and perform operations-planning as well as query, edit and save data to various databases in the Database tier. These management systems enable student officers to rapidly and efficiently develop assumption and operation plans. The designs for these three management systems are based on the ECM module provided by MOSS 2007.

4.2. Experimental evaluation of learning effectiveness

The goal of this study is to develop a Petri-Net approach for analyzing and designing a distance learning system for advanced military education. With the aid of the Petri-Net model, the designer can easily spot the learning curve of this course and design an appropriate e-learning system. For example, according to the discussion in Section 3.4, the Petri-Net analysis in Fig. 8 clearly indicates that stages T3, T4 and T5 are the learning curves for officer students. Stage T10 also affects learning effectiveness. To further verify this point, an experiment is conducted to determine whether the Petri-Net analysis is consistent with actual conditions.

Hence, based upon the above four crucial stages, the following five learning effectiveness measurements are chosen for validity testing of the DL4AME:

- **Impact on engagement planning:** This indicator evaluates the ease with which the officer student completes stage T3, i.e., the assumption development and operation planning stage. The “Joint Operations” course requires officer students to construct and test different assumptions. With the aid of assumption management, the officer students can easily adapt an existing assumption from the Assumption database to reduce setup time. Similarly, the wizard provided by the Operation-planning management helps the student to complete operation planning procedures.

- **Battle reaction and decision-making capability:** This indicator represents the effectiveness of the student in battle reaction and decision-making. This training is provided in stage T5 (Fig. 8). The objective of the “Joint Operations” course is to develop the reaction capability and decision-making of officer students under combat conditions. In the on-campus course, an interactive war game system is
used as the training platform. However, given the asynchronous nature of distance learning, the interactive war game system is replaced by an analytical model. Through the process of setting different parameters in repeated simulations, officer students can acquire the expected decision-making capability.

- **Case studies:** During joint operations practice, officer students must select appropriate simulation models. As stage T4 in Fig. 8 shows, this indicator measures the practicability of the simulation models selected by officer students. The capability of selecting appropriate models is the target goal, which can only be developed by repeated case simulations. In addition to teaching templates, the model repository provided by DL4AME can easily provide examples from previous exercises. Meanwhile, the reiteration characteristics of the model enable officer students to accumulate combat/operation experience under varying engagement scenarios and parameter settings.

- **Sharing learning experiences:** This indicator evaluates the usefulness of group discussions (stage T10 of Fig. 8). The DL4AME integrates communication systems that enable online group discussions among officer students. The last step of the on-campus “Joint Operations” course is an after-action review meeting of all officer students and the instructor to share their respective simulation experiences. The after-action review meeting is an important activity that can significantly enhance the learning achievement of the officer students. The DL4AME uses a combination of various network communication tools to conduct this activity via Internet.

- **Overall learning effectiveness:** This indicator compares overall learning effectiveness between the on-campus program and DL4AME in the “Joint Operations” course. This indicator requires each officer student to evaluate whether the DL4AME was as effective as the on-campus program.

After exploring the above five learning effectiveness measurement indicators, a questionnaire was designed to survey a group of ten officer students. All students were currently enrolled in advanced military education courses: five were currently taking on-campus programs, and five were currently taking correspondence courses. All students were first asked to describe their experience in the “Joint Operations” course by DL4AME with a textbook war game exercise. In stage T10, the students participated in an on-line discussion. Finally, questionnaires were e-mailed to the students with instructions to return the questionnaires within a week. This survey attempted to gather feedback from officer students to determine whether DL4AME met their expectations. Table 2 summarizes the questionnaire results.

### 4.3. Discussion

The survey revealed several interesting results for these five measurement indicators:

1. **Impact on engagement planning**: Table 2 shows that approximately nine out of ten officer students (i.e., 92%) agreed that DL4AME helps to simplify planning work. By accessing the database of assumptions and operations-planning by former students, DL4AME considerably reduced the planning time of current officer students. Thus, this indicator received a relatively high score.

2. **Battle reaction and decision-making capability**: This indicator indicated that 84% of subjects agreed that DL4AME increases the effectiveness of the student in battle reaction and decision-making. Since the analytical model is widely used as a decision-making tool, officer students can gain substantial experience by iterating the simulation from different scenario settings. These experiences enhance the capability of officer students to make correct decisions and react properly on the battlefield. Hence, most officer students agreed that the Scenario setup function helped them make correct decisions through repeated settings of simulation.

3. **Casebook learning**: The positive response to this indicator was lower: 74%. The possible reason is that the officer students were still unfamiliar with DL4AME simulation models. Compared with the original correspondence course, DL4AME enabled officer students to accumulate experience by operating the analytical model. Further interviews with the test subjects indicated that the existing models in the DL4AME failed to fulfill their needs. Hence, more models are required to meet diverse course demands.

4. **Sharing learning experiences**: Agreement for this indicator was 82%, which indicates that the commercialized video conference system combined with the electronic whiteboard system for group meetings were comparably effective for after-action review meetings on campus. Although video conferencing is still less efficient than face-to-face discussions, the feedback from the subjects indicated that the DL4AME meeting tools were still highly effective.

5. **Overall learning efficiency**: Overall, 84% of the officer students agreed that the DL4AME system was more effective than the correspondence courses. Although the DL4AME system did not achieve the same learning objectives of the on-campus program, the survey results indeed indicate the potential of DL4AME after further refinement.

<table>
<thead>
<tr>
<th>Officer student</th>
<th>Impact on engagement planning</th>
<th>Capability of battle reaction and decision making</th>
<th>Learning from casebooks</th>
<th>Sharing learning experiences</th>
<th>Overall learning effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Average</td>
<td>4.6</td>
<td>4.2</td>
<td>3.7</td>
<td>4</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Agreement: 5 = same with the on-campus course, 1 = same with the correspondence course (AME courses is to train the candidates for promotion to colonel and major general. The officer students of AME program are rare).
Fig. 11 depicts the survey results in further detail. The statistical chart shows that most officer students agreed that the learning effectiveness of the “Joint Operation” course by DL4AME was closer to that of an on-campus program than to a correspondence program. Compared with the correspondence program, Fig. 11 shows that DL4AME provided the advantages of asynchronous remote learning by correspondence program without compromising the learning efficiency of the on-campus program.

5. Conclusion

The AME correspondence courses have been operated by Taiwan military over the past fifteen years. This approach provides the flexibility needed by active duty officers to improve their military knowledge (Mitchell, 1996). Although the AME correspondence course provided active duty and geographically distributed officers with continuous educational opportunities, interaction with the instructor and other classmates was a major obstacle in the learning process. Advances in e-learning technology provide improved support for remote education. With the rapid development of computing and Internet technologies, e-learning programs have been studied intensively by the military in the recent years.

This study developed a systematic method for designing e-learning systems according to specific requirements of target courses. The proposed approach started by comparing on-campus programs with existing e-learning systems to identify the steps required to transform the program into an e-learning system. After first outlining the pedagogy of the on-campus program, its proposed teaching flow over the Internet was then sketched. Finally, the Petri-Net model was used for in-depth analysis of the stages affecting the learning curve. The example of a “Joint Operations” AME course elaborated the presented approach. An e-learning system prototype was also designed accordingly. Finally, an experiment was conducted to verify the efficiency of the presented approach.

The above experiment indicated that the “Joint Operation” course for DL4AME successfully achieved the goal of asynchronous remote learning without compromising learning effectiveness. However, the experiment also revealed that, to make the system more effective, supported databases must be augmented with more war game exercises and template information. Further, surveys of officer students are needed to improve the DL4AME user interface. Finally, online versions of other on-campus courses are currently under investigation. Ultimately, this study focused on replacing the current AME correspondence program in Taiwan with an e-learning program.

References


Russell, T. L. (1999). The no significant difference phenomenon. Instructional Telecommunications, North Carolina State University, Raleigh, NC, USA.


