

Teaching a Second Core Course in Information Technology: A West Point Experience¹

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Abstract – The United States Military Academy (USMA) at West Point has the mission to produce officers for the U.S. Army. As part of the curriculum, the Academy requires all non-ABET major cadets (students) to take two courses on information technology (IT) with both courses focused on problem solving with technology. The first course is an introductory course offered in the freshman year while the second course is a more detailed course offered in the junior year. The Electrical Engineering and Computer Science Department uses an expanded definition of information technology; that is, any technology that acquires, transmits, processes, or displays information. Information technology is becoming increasingly important in the Army with the development and use of sensors, command and control systems, and other technologies to achieve information dominance. The course is divided into six modules: acquisition of data and sensors, transmission of data and networks, processing of data into information, display of information, legal and ethical issues of IT, and information dominance and operations. Cadets use a four-step problem solving methodology to develop and implement the components of an Information System to solve a real-world problem. The short-term impact of the course on the cadets has been very positive, and we are confident that the long-term impact will be substantial on the cadets and the Army. Cadets are exposed to a number of different technologies, gaining an understanding of how these technologies are used to acquire data, transmit data, process data into information, and display information to support decision making. In addition, the course projects help enforce the problem solving methodology where cadets analyze, design, implement, and test their solutions.

Keywords – information technology education, active learning, information systems engineering.

INTRODUCTION

The West Point mission is “to educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country; professional growth throughout a career as an officer in the United States Army; and a lifetime of selfless service to the Nation.” In parallel with the contributions of the military and physical programs at United States Military Academy (USMA), “...the purpose of the Academic Program’s curriculum is to set the intellectual foundation for service as a commissioned officer”. To provide this academic foundation, every graduate must demonstrate proficiency in six domains of knowledge (engineering and technology, math and science, *information technology*, history, culture, human behavior) and be able to: think and act creatively; recognize moral issues and apply ethical considerations to decision-making; listen, read, speak and write effectively; and, demonstrate the capability and desire for continued intellectual development. Proficiency in IT is further delineated by what graduates can do [1]:

- Understand how systems based on information technology work.
- Understand how to employ information technology systems.
- Understand how to use IT to solve problems and make decisions.
- Understand the underlying physical and mathematical concepts relevant to IT; and,
- Understand the importance and implications of IT and digitization.

¹ Opinions and views expressed in this paper are those of the authors and do not reflect the official policy or position of the United States Military Academy, the Department of Defense, or the U.S. Government.

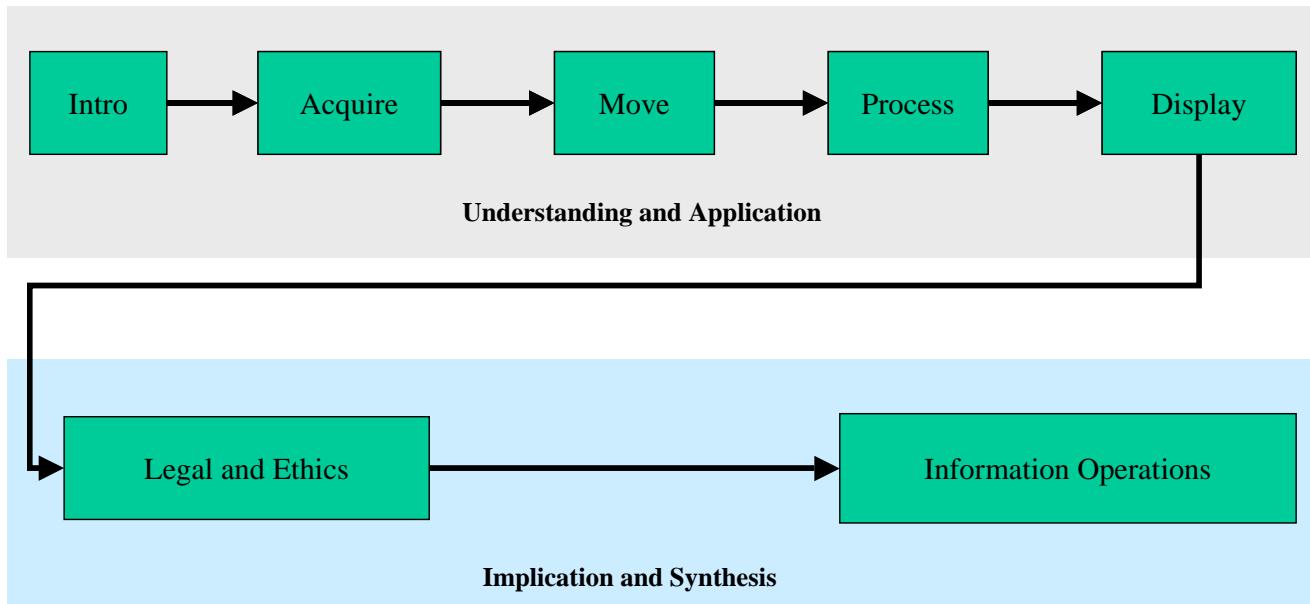


FIGURE 1: IT305 MODULES

Proficiency in IT is the most recent academic goal and was driven by changes in the Army and the world. The Army has placed increased importance on information technology in the last few years to achieve operational dominance. As the Academy assessed information technology at West Point, it found that cadets use information technology extensively in the curriculum and in the barracks. The Academy requires all cadets to own and use a personal computer and a personal digital assistant. Starting last year, this computer was a laptop. The barracks and classrooms are extensively networked and technology use by cadets and faculty is widespread and commonplace. Cadets use technology daily.

Cadets also took a core courses in information technology. During their freshman IT course, cadets learn the basic programming principles of sequence, selection, and iteration while implementing Java programs and the basic principles of IT. They build sensors by soldering electrical components together and then write Java programs (approximately 200 lines of code) to control robots that use their sensors as input devices.

The Academy's assessment of IT determined that the widespread use of IT and the first course in IT were not sufficient to meet the needs of the Army and satisfy the requirements of the IT goal statement. A second course was necessary to let cadets build a complete information system and explore the implications of technology in the Army and on society.

USMA began offering a second IT course (hereafter referred to as IT305), taken during a cadet's junior year. This course expands on what is learned in the first course, providing more detailed, hands-on instruction on the types of Information Technology cadets will use as future officers. Because of the types of technologies that the Army is fielding and utilizing, USMA expanded the traditional definition of IT. Traditionally IT is defined as computer or networks technology or computing with networks. USMA expanded upon this definition to include any technology that acquires data, transmits data, processes data into information, or displays information. Our definition includes sensor and other data acquisition technologies as well as technologies that allow dynamic displays of information. This paper discusses the architecture of the new IT course, some initial results of using the curriculum in prototype sections, and the future plans for the course.

METHODOLOGY

Overview

IT305 includes 40 lessons during a semester, stressing problem solving using information technology. The course is divided into six modules (Figure 1): acquisition of data and sensors, transmission of data and networks, processing of data into information, display of information, legal and ethical issues of IT, and information dominance and operations. These modules form two "loops" through the course material. The first four modules focus on cadets understanding the underlying principles and application of information

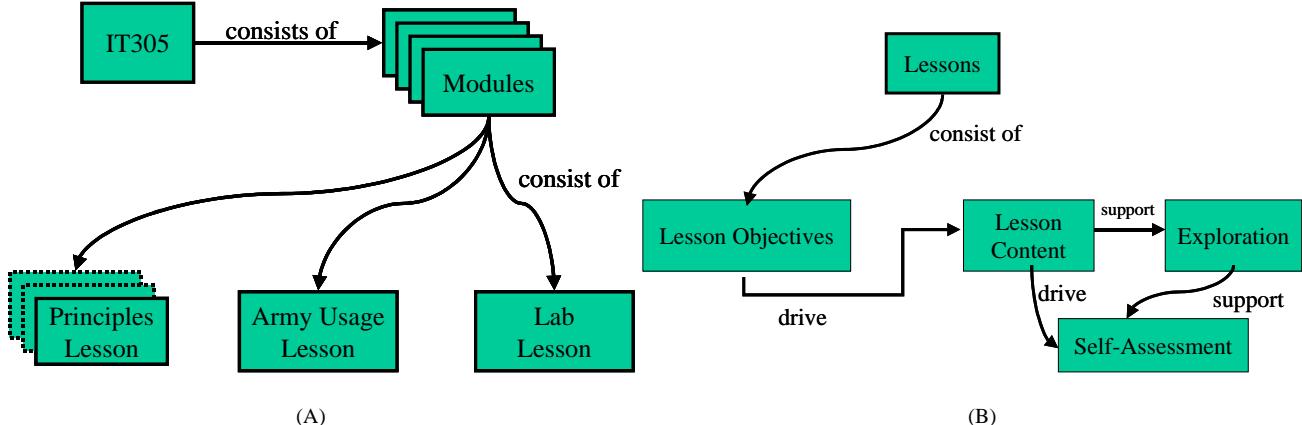


FIGURE 2: (A) MODULE DESIGN AND (B) LESSON DESIGN

technology. The last two modules in the course revisit the material covered in the first four modules but cover it at a different cognitive level focusing on the implications of technology and a synthesis of the IT components.

Modules

The content of each module is based upon the premise that we wanted cadets to understand the underlying principles behind the technologies, then provide them with a lesson on Army uses of the technology to show relevancy, and finally extensive hands-on experience with the technology (Figure 2a). For example, it is necessary but not sufficient for cadets to understand networks from a theoretical perspective. Cadets must also know how networks are used in the Army (we use the Mobile Subscriber Equipment InfoFlow simulation and allow cadets to build data networks on the virtual battlefield) to show Army relevancy. Finally, cadets design and build a real network using real computing devices, hubs, switches, and routers. Each module follows this basic design of principles, Army usage, and practical lab.

Lessons

Modules consist of lessons and lessons have an underlying architecture (Figure 2b). Lessons consist of lesson objectives that are concise, consistent, and constructive. We built lesson objectives using Bloom's Taxonomy [2] as a guide so that the verbs used in each lesson objective convey concisely the required depth level of preparation. This improves communications with cadets by explicitly depicting instructor expectations. Lesson objectives are constructive in that they build on each other starting with knowledge and comprehension objectives and culminating with synthesis level tasks. These lesson objectives drive presentation of content and classroom activities. Classroom time is allocated to tasks that cannot easily be conducted outside the classroom focused on cadet led inclass exercises. There are twenty-

three inclass exercises over forty lessons ensuring that the course is not lecture-based but instead focused on active learning. Lesson objectives and content drive cadet assessment. As discussed by Montgomery, there must be a direct linkage between lesson objectives, course content, and assessment or student confusion will occur [3]. IT305 makes the relationship clear by including the lesson objective identifier with every question on the course exams and the final. This procedure also serves as a double-check with instructors that the questions asked are fair. It promotes a grading system that is as transparent as possible concerning requirements and minimizes grade curving.

Assessment Plan

Cadets are assessed through three written exams and five projects. The written exams evaluate cadet retention of IT principles at lessons 15, 27 and a final exam. The five projects are implemented as two-man group projects that require cadets to implement components of an Army information system. The first project is a pass/fail evaluation and requires the cadets to build a web portal for their classroom experience. For the second project, cadets design a Local Area Network for a company-sized (100 person) unit. Cadets design and implement an Access database during the third project and then build a web-based portal to the database to display information from the database during the fourth project. The final project expands on what the cadets have built already while requiring them to develop a complete information operations plan.

Complementing the evaluation plan is a series of twenty-three inclass exercises and a Java servlet-based self-assessment system. As Seger discusses in [4], students learn and retain more by doing as opposed to hearing or seeing course material. The end result is that the cadets are receiving feedback constantly throughout

the course and actively learning not by lecture, but by doing.

MODULE CONTENT

Each of the course modules is discussed below.

Acquisition of data and sensors module

During this four-lesson module, cadets learn the principles of acquiring data from our “analog” world and digitizing it into a digital format that can be transmitted and processed. The process of digitizing audio, visual and other waveforms from the Electromagnetic Spectrum is discussed. Cadets learn and use lossy and lossless compression schemes to compress data. One lesson is spent discussing the Army sensor technologies that are used on the battlefield including Unmanned Aerial Vehicles, satellites, Night Vision Devices, and ground sensors. In the final lesson, a hands-on lab is conducted where cadets use a digital audio editor to acquire audio data, manipulating the sampling rate and size while acquiring the data.

Transmission of data and networks module

During this seven-lesson module, cadets learn the principles of communications and data networks. In the first lesson, cadets learn the principles of communications including the Radio Frequency Spectrum, the advantages and disadvantages of using wired and wireless communications, and differences between analog and digital communications. During the second lesson, the principles of networks are introduced with cadets learning about the basic components of a network and the organization of the Internet. Two lessons are spent learning about network devices and protocols with extensive discussion on TCP/IP. One lesson is spent learning about Army communications and networking systems. The final two lessons are spent with the cadets designing a Local Area Network and then implementing their designs using the network devices and protocols discussed in the previous lessons (Figure 3).

Processing of data into information module

During this five-lesson module, cadets review the principles of processing on computers, including the hardware and software involved with processing data into information. In the first lesson, cadets learn the principles of the hardware of a computer and the different file systems used on a computer. During the second lesson, cadets are given the opportunity to disassemble a PC, reviewing what each component does and then put it back together. Two lessons are spent learning about databases, getting hands-on experience with Microsoft



FIGURE 3: CADETS BUILDING CLIENT-SERVER NETWORK

Access while building a very simple database in class. The final lesson is spent learning what processing systems the Army uses for command and control on the battlefield, giving cadets hands-on experience with one of the systems they will use in the Army.

Display of information module

During this six-lesson module, cadets work extensively with the HyperText Markup Language (HTML), client-side executables, and server-side executables to implement dynamic displays. In the first lesson, cadets learn the principles of the display technology and review the basics of HTML. During the second lesson, cadets work with HTML forms and image maps. The next lesson cadets learn about client-side executables, using JavaScript to error-check an HTML form. The next two lessons cadets learn about server-side executables, using Personal Home Page (PHP) to retrieve and put data into an Access database. In the final lesson, cadets work with an Army command and control system’s dynamic displays.

Legal and ethical issues of IT module

During this three-lesson module, an instructor from USMA’s Department of Law leads a discussion with the cadets on several legal and ethical issues including privacy and national security, IT-based intellectual property, and some unique issues of using information warfare on the battlefield.

Information Dominance module.

During this eight-lesson module, cadets learn what information dominance is and how the Army plans to achieve it on the modern battlefield. Three lessons are used to discuss information dominance and how the Army plans to acquire, transmit, process, and display information to achieve operational dominance. Four lessons are used to teach cadets about information



FIGURE 4: CADETS WATCHING NETWORK TRAFFIC USING SNIFFERS

operations. During these lessons, cadets learn about the tools and techniques used to conduct an information system attack, and the tools and techniques used to prevent these attacks. Cadets work with firewalls, network sniffers, and a network intrusion detection system (Figure 4).

COURSE TEXTBOOK

Many IT courses use a single book as their course text. Because of the unique nature of this course and most IT textbooks are not technically rigorous, we created customized textbook. This textbook required parts of five different textbooks. In addition to the textbook, the course uses reading from the web and several reading from military journals.

ASSESSMENT

Initial Prototype

The course has been offered for two semesters as part of an initial trial. Cadets completed web-based surveys after each module as well at the end of the semester. The surveys polled cadet opinion on the course content, including textbooks, material presented, the instructor and their workload. Cadets were also asked how to improve each module and the course overall. We used the cadet feedback to improve the course. Several notable statistics from these surveys include:

- ❑ 97% of the cadets felt the instructor related IT to the Army.
- ❑ 91% of the cadets felt the course prepared them to work with IT.
- ❑ 88% of the cadets felt their ability to critically think improved as a result of the course.
- ❑ Of the 717 comments received on the course and its modules, 85% (605) were positive and 15% (112) were considered negative.

- ❑ The most popular modules were information dominance and the legal/ethical modules. The least popular course component was the final project (43 positive comments and 13 negative comments).

Overall, cadets responded very favorably to the new course. They especially appreciated the relevance and applicability of the course. Cadets felt this course prepared them for careers as Army officers and to work with IT. Several cadets have heard about the course trial and are now taking it as an elective. The best result is the cadets are using what they learned. Every cadet that took the initial prototype is using the course in other courses according to surveys conducted the following semester. Academics at West Point is going to change as a result of this information technology course and that change is already underway.

More impressively, four months into the subsequent semester, 22% of the cadets in the first prototype (8 cadets) had already developed and implemented information systems outside the classroom to solve real-world problems. Another cadet is in the planning process to implement a system for the cadet scuba team. Organizations such as the American Chemical Society, Center for Enhanced Performance, Class Pistols, National Service Agency Inter-Academy Security Competition, as well as two cadet companies have already benefited from IT305.

First Semester Results

Approximately 340 cadets took the course in the first semester of academic year 2004. The information technology program director interviewed 8.7% of the course students to assess the effectiveness of the initial offering of the course. Typically the interviews went one hour and were conducted in the program director's office. In four cases, two cadets were interviewed at the same time due to scheduling conflicts.

Each interview followed the same agenda. Cadets commented on the first five modules in the course (sensors, communications, processing, display, legal/ethical) in terms of length, relevancy, and conduct of the lessons. Comments were not collected on the last two modules (information dominance and information assurance) due to when the interview process started. Cadets then commented on each of the evaluations in the course (Web Portal, Network Design, Database, and HTML Display) in terms of relevancy, difficulty, and execution. Finally, cadets commented on the overall course relevancy and the degree they understood the implications of technology.

The results of the interviews provided insight to the effectiveness of the course and cadet perceptions of the course. The majority of cadets interviewed (87%) found the course relevant to their perceived cadet and Army experience. Fourteen cadets (47%) found the course and all modules highly relevant. A typical comment was “*Relevant. I am partial to networking.... The database is right in your face. The web-based forms are right in my face.*” One cadet (3%) found the entire course irrelevant and articulated, “*Not very clear of all. I am never going to use any of this.*”

These results are encouraging. Cadets see the course as relevant. What was problematic was that cadets are not seeing the relevance of the course consistently throughout the entire course. The course consists of two loops through information technology with the first loop focusing on the underlying principles and the second loop exploring the implications of technology. During the first loop, the cadets often asked the question “why am I doing this?” During the second loop, the majority of cadets understood the answer and thus the positive results. The course provides a “why this is important” component on each lesson webpage. We may be able to increase course relevancy early in the semester by linking the bigger picture of course structure in the classroom earlier in the semester.

To a certain extent it was surprising the number of cadets that saw the implications of technology and improved in their confidence in using technology. Implications of technology was defined as the degree of confidence to use the course material to support military decision making. It is high standard. Twenty-seven cadets (90%) felt they understood the implications. The comments were positive and included:

“Oh yeah - it is a well-needed course in terms of the changes in technology - a lot of the same stuff we did. I enjoy this more than freshman year. Seeing stuff happening was the best.”

“Getting it. My ability to troubleshoot an IT problem has increased tenfold. I will forget the details but I am more likely to spot an IT problem as a result.”

“I think FBCB2 really got to a lot of classmates. Just seeing how it is used. A lot of folks want to work with it more. Just to have time to play around with it in a less structured mode.”

Three cadets (10%) did not get the implications at all. One cadet stated, “*Missing it - going over my head. Not the biggest fan of IT*” while the other commented, “*Did not know you were suppose to be getting the implications of technology*”. Another cadet suggested,

“I am not sure I understand what the purpose of the course. The lesson objectives are too specific to get to implications - can we move to implications directly?”

It is important to reemphasize that the purpose of the course is to understand the implications of technology. The methodology to achieve this goal is to discuss the fundamental principles initially as a basis for informed discussion later in the course. The conversation would be shallow without an understanding of the fundamental principles.

Overall, the results from the two prototype sections coupled with the thirty hours of interviews validated the design and implementation of the course while providing valuable feedback to enhance the course. Plutarch is quoted as saying “A mind is not a vessel to be filled but a fire to be kindled”. The IT flame has been lit in these cadets. Time will tell the impact the resultant fire will have on the Academy and the rest of the Army.

FUTURE ENHANCEMENTS

There are several enhancements that are planned for the course in the future. Work will soon begin on constructing exportable modules as part of a Computer Based Training (CBT) package. The CBT module will allow other departments to include components of IT305 in their courses so that the material can be discussed from a different disciplinary perspective. We also want to produce a CBT package for officers to use to increase their knowledge of how the Army uses IT today. Our officers understand Army operations but may lack an understanding of emerging technologies. Work is underway to automatically color-code lesson objectives by the depth requirement (with respect to Bloom’s Taxonomy) to more visually display lesson objective depth requirements and communicate expectations better.

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