Diversity in Uniform: An Approach To Teaching Introductory Information Technology

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In a school where every single student dresses exactly the same as every other student every day, often called the “sea of gray”, where each person learns to sit, stand and walk exactly the same way and each will participate in the same summer jobs, and where all graduates will be hired to work by the same organization in essentially the same job, diversity couldn't be an issue, could it? When every student in each incoming class receives exactly the same computer system and takes exactly the same introductory technology course, Information Technology education is anything but diverse, or is it? While the students, called cadets, all dress exactly the same, they offer a wonderfully rich and diverse population, both in their culture and in their familiarity with and knowledge of information systems. The United States Military Academy (USMA) at West Point admits between 1,200 and 1,400 young men and women each year. This population is intentionally drawn from every state and approximately 30 foreign countries. The group is representative of the broad range of ethnicities, cultures, backgrounds and experience that comprise the melting pot that is the United States. The first six weeks of their experience brings them together to function as members of a team with a common bond. Therein, each cadet must take approximately four semesters of a rigorous core curriculum. Upon graduation, each will earn a Bachelor of Science degree after completing the core curriculum along with advanced studies in a selected major and exposure to one of several engineering disciplines.

Cadets' core curriculum includes two courses in Information Technology. The first course, IT105, emphasizes IT-enabled problem-solving. It is designed to establish a foundational knowledge in Information Technology systems, web technologies and to foster an understanding the basis of computer programming. Many of the cadets have some previous experience with computers, but a rare few have the required breadth of knowledge in all aspects of information technologies upon entry to USMA that is provided in the IT105 course. Some have limited experience and yet others have never even used a computer prior receiving the one issued to them shortly following their arrival to the academy. The IT105 curriculum is designed to provide every cadet with an initial conceptual framework and to develop fundamental skills necessary to be successful during their four years of academic and military development at USMA. A cadet's IT skills and knowledge are refined throughout their 47 month integrative experience. The challenge is to provide a common experience while recognizing the individual. To that end, IT105 uses a broad range of tools, examples, experiences, and assessment techniques to establish this common foundation across the spectrum of starting points. We have designed the curriculum, the assessments and the teaching pedagogy to build a solid foundation today for the nation's leaders of tomorrow. We rely on a heterogeneous blend of technologies and platforms in order to give faculty the necessary flexibility to address each student's needs while meeting clearly specified outcomes.

Background

The purpose of the United States Military Academy is to provide the nation with leaders of character who serve for the common defense. In order to integrate itself, and hence the Army officer corps, the

U.S. Military Academy has self-consciously attempted "to balance the Corps" and therefore has "develop[ed] goals for each class for desired percentages of scholars, leaders, athletes, women, blacks, Hispanics and other minorities." [1] The academy also seeks diversity in the faculty, not only with respect to race, ethnicity, and gender, but additionally in military experience and perspective. Combine class sizes limited to 18 cadets per section with a core course presented to each of the 1,200-1,400 cadets per year, and you have more than 30 sections of the course taught each semester. Even with several instructors teaching four sections, this generally demands between 10 and 15 instructors per semester. The cadets are not the only diverse population; the faculty is comprised of a diverse population as well. The faculty is categorized and selected within each of three groups and the overall composition is approximately 1/3 of each. The three groups are permanent military faculty who provide strategic vision and continuity, civilian faculty intended to provide academic focus and perspectives beyond the military, and rotating junior military faculty temporarily assigned to USMA to provide direct recent, practical military experience. The design of the course must take into consideration the diversity of the faculty who will be instructing the material, as well as the diversity of the learners.

The military has long been at the forefront of the nation's efforts to enhance equal opportunity, but recently the focus has shifted from merely providing opportunity to those less advantaged to actually recognizing the value and benefits returned through diversity. The Leading Diversity Process Model (LDPM), Figure 1, proposed by Colonel André Sayles, has been adopted by for use throughout the Department of Defense. The LDPM has three primary components of accept differences, understand

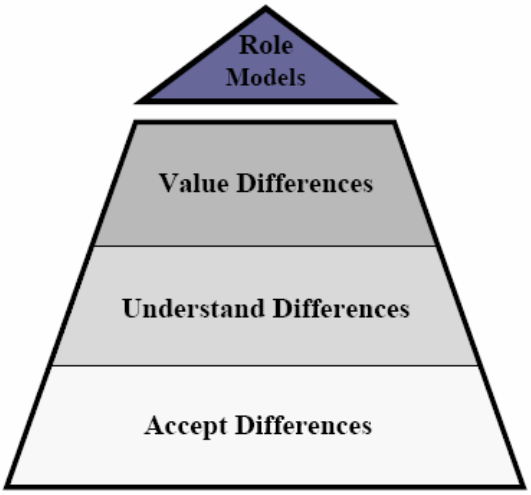

Figure 1. Leading Diversity Process Model [2]

differences and value differences [2]. As leaders and educators, we seek to identify and value differences among our cadets and to leverage those differences to enhance understanding for the group. We also seek to help cadets to value the differences among their peers, subordinates and leaders. The need to produce leaders of character is a direct complement to the academic requirements.

USMA's educational process focuses on the development of the whole person. The academic, military, physical, and moral/ethical development of each cadet is accomplished through an immersive 47 month experience. The stated goal of the academic program [3] is to enable graduates to anticipate and respond effectively to the uncertainties of a changing technological, social, political, and economic world. As a result, the curriculum has a core program in both the humanities and social sciences and in the basic and applied sciences.

The overarching goal of the academic program at USMA is "to enable its graduates to anticipate and to respond effectively to the uncertainties of a changing technological, social, political, and economic world." In his strategic guidance, the dean of the academic board further states "*Army leaders of the 21st Century must understand and employ technology. Technological advances will continue the trend toward improved precision. Global positioning, high-energy research, electromagnetic information systems, and enhanced deterrent capabilities will be continuously refined and incorporated into military operations. In defending our national interests, Army leaders must be sophisticated users of advanced technology and comfortable employing scientific, mathematical, and engineering concepts to solve national security problems.*"[3]

Pedagogy

The goals of the IT105 course are designed to support this vision and set of priorities. It is the first of two courses intended to bolster the dean's vision within Information Technology, one of six identified domains of knowledge for the academic program. The five goals of the IT105 course are designed to support the dean's vision and are stated below.

1. Understand the underlying physical and mathematical concepts relevant to IT.
2. Understand how IT systems function.
3. Understand the methods for successfully employing IT.
4. Effectively use IT to solve problems and make decisions.
5. Understand the importance and implications of IT.

The pedagogy employed in the design of the IT105 course is to recognize and appreciate the diversity of the cadets, the faculty, and the topics in the course. IT105 is an introductory course in the understanding and application of IT. We focus on an understanding of the underlying principles and on the employment of technology to solve problems (see Figure 2). We seek not to teach any single technology, but rather to use technology to develop an understanding of the underlying principles that can be applied now or at any time in the future in the context of a technologically rich military organization. IT105 focuses on the fundamental concepts of understanding what is a technology system, a computer, and how does it work. The follow-on course, IT305, focuses on applying those fundamental concepts in a military context.

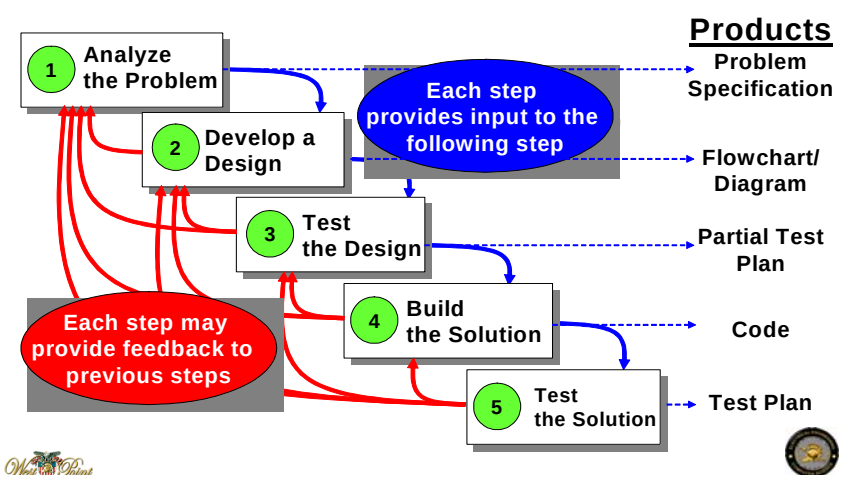

Figure 2: IT105 Problem Solving Process

IT105 uses many techniques to address the broad range of understanding from which our cadets enter. We design each lesson, each exercise and each graded requirement with this fact in mind. We seek to guide and develop in a very well-defined and constrained environment those with limited understanding of either the topic or the educational process. We seek to provide open-ended opportunities for exploration for those with a greater depth of knowledge or those who are more mature learners. The tools that have been selected for the course are designed to enhance the understanding of the topic despite the many facets of cadet diversity [4]. While we agree with [4] that we cannot tailor every bit of content to exactly fit every student, we seek to ensure that the overall experience provides content for varied learning styles, approaches to learning and levels of intellectual development.

While this is an introductory course in Information Technology, we seek to provide the cadets with an understanding and an intuition regarding how an information processes and manipulates information rather than teaching a specific skill. While we use skill development, the underlying goal is to produce cadets and ultimately officers with an understanding IT systems such that they can go beyond using a system as provided, and be able to identify and evaluate potential enhancements to an IT system. We focus on the content of the course, the tools used to enhance learning and the assessment mechanisms in order to educate cadets in the field of information technology.

The course content is based upon extensive analysis of the issues associated with Information Technology education and an understanding of the cadet population. The Army identifies how IT systems and information are to be leveraged in future military systems. [5] We considered the recent effort [6] to describe the emerging IT discipline as including five key areas: Programming, Networking, Web Systems, Databases, and Human Computer Interfacing and goes on to argue that "we have come to understand that IT students require depth, but not depth on how to implement technology components. IT students require deep knowledge of the interfaces between technologies." With this work and work done here at USMA [7], we partitioned the foundational knowledge between IT105 and IT305 with a focus on IT105 providing a stable foundation of knowledge and skills for cadets to be successful during their academic studies here at the Academy. The primary topics of the course include (1) Understanding the Components of an Information System, (2) Using a Problem Solving Methodology, (2) Design and Implement an XHTML web site, (3) Design and Implement General Purpose Programming Solution and finally (4) Explore the Current State of the Art and likely Future Enhancements to IT Systems. Throughout the course, we seek to provide a breadth of knowledge and a level of understanding that would facilitate deeper investigation of any given topic or issue. The lessons ensure that each cadet in any of the over 30 sections of the course receives a common foundation. This is challenging because not only must we value diversity in the cadets, we must also recognize and value the diversity of our faculty. The course employs military and civilian faculty with backgrounds throughout the spectrum of information technologies, computer science, electrical engineering and information management. We attempt to leverage individual experiences during classroom interaction while defining a common baseline of information. Our faculty development workshop and mentoring program [8] provide the requisite thread of continuity for the faculty.

Tools

In this section, we examine and discuss a broad range of tools used to support the pedagogy described in the previous section. In developing an introductory IT course that is required of all cadets regardless of potential major, we have found that there is no "silver-bullet" technique, tool or approach to teaching that is best suited for the varied levels of experiences and learning styles that we encounter in the classroom. Keeping that in mind, we have adopted more than a handful of different applications to help us teach IT fundamentals, web design and programming, logical control and complex problem solving. While we have accepted some risk in doing so, experience has taught us that the more flexible, adaptable and interoperable a tool is, the more helpful it is in helping us achieve our objectives.

The computing environment that supports academics at USMA is largely homogenous and undifferentiated. Cadets from each entering class are all issued the exact same technology package. In recent years, this includes a notebook PC, multi-function printer and other peripherals. The PCs run Microsoft Windows operating systems and come with many programs, including Microsoft Office, Mathematica, and other academic software. Much more software is available for cadets to download under site license agreements. While the PCs are considered the individual private property of each cadet, they operate on a managed government network. Commercial ISPs are not available to the cadets. As such, each computer must maintain configuration requirements (ie – a properly patched and updated issued version of Windows as the operating system, anti-virus, malware detection engine and other client security applications) in order to access the network.

Despite this seeming homogeneity, the automated tools and platforms that are used to support instruction in IT105 are varied, diverse and largely interoperable. Since IT105 emphasizes problem-solving as opposed to strictly programming, learners must acquire and refine skills in analysis, design, testing and coding. In order to give treatment to the concepts of analysis and design, we have collaborated with the faculty at the U.S Air Force Academy (USAFA) to provide a flowcharting application that serves as a visual means to design and construct logical processes and algorithms. This freeware application, called Raptor, is being used by several institutions in addition to ours and USAFA to teach IT fundamentals. More than simply a flowcharting program, users can "run" or "step through" flowcharts in Raptor as if they were programs. Moreover, the developers of Raptor have recently added the capability to translate Raptor flowcharts into stub code in several high-level languages. We have developed our own plug-in for Raptor that allows users to generate Java stub code that includes method calls from our instructor-provided wrapper for learners.

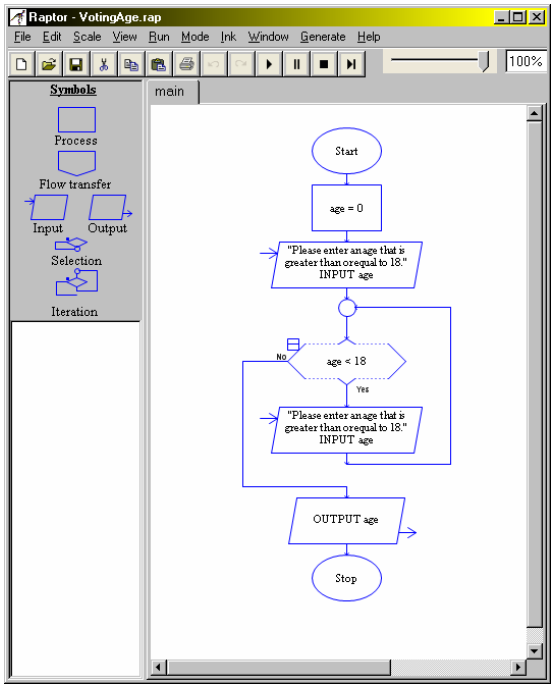

Figure 3. A Raptor Flowchart

Raptor is written in C++, C# and Ada, and is delivered as a Win32 executable program. Plug-ins are written in C#. Since the source code is controlled by Raptor's developers at USAFA, updates and changes are coordinated in advance of new releases. As Raptor is updated, we make it available for download and installation using Microsoft Windows Installer. We average about one update per semester. All cadets enrolled in IT105 must be running the most current version of Raptor. While our faculty contribute to the Raptor development effort, we do not have exposure to the source code or APIs for this project.

As mentioned, Raptor generates stub code in our primary teaching language - Java. Along with developing visual algorithm representations in Raptor, cadets must also master the fundamentals of text-based programming in a high-level language. While learners are not required to write text-based programs by hand from scratch, they must learn to edit, compile, modify, run and use Java programs created as stub files from Raptor. These programming efforts take place in a lightweight integrated development environment (IDE) that has been created and maintained by our faculty for about 6 years. The IT105 Editor is part of a sizable Java software project that provides not only the IDE, but also a framework for deploying student problems along with integrated test cases, various utilities used for teaching and assessing student work,

and other programs. The framework for deploying student problems, called the Problem Set Manager, allows faculty to devise problems that underscore foundational design and programming concepts and then develop an XML-based file that includes the problem context, example input and output and a set of specified inputs and expected outputs. These problems are exposed via the network and cadets can test their programs against these specified test cases to determine if they have arrived at a solution that produces the correct output. While the Problem Set Manager is integrated into the IT105 Editor, it can also be run as a separate module in conjunction with alternative IDEs. The most significant application in this project is the IT105 Editor. This custom IDE can parse Java programs, XHTML-based web pages and Cascading Style Sheets and provide compilation or validation feedback to the user. The IT105 Editor is written entirely in Java and is deployed to users as a Java Network Launching Protocol (JNLP) application. JNLP technology allows us to make changes and upgrades to the Editor available to cadets for immediate download each time they launch the application while connected to the network. This provides a high degree of flexibility and robustness in developing and maintaining the application. At its core, the IT105 Editor is based on an earlier version of an open-source text programming environment called jEdit. Several of our faculty have contributed to the development and maintenance of the IT105 Editor and other applications in our project.

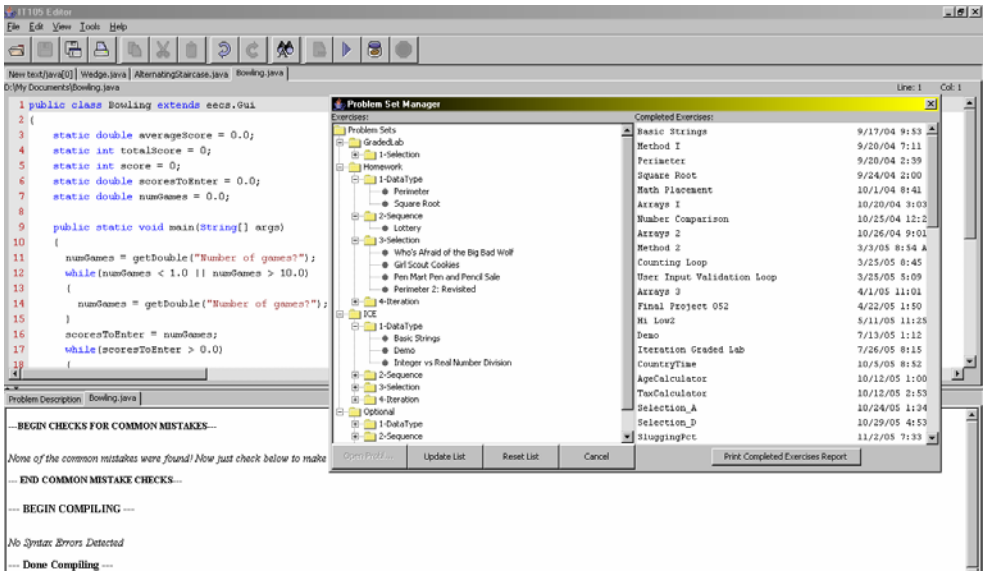

Figure 4. Screenshot of the IT105 Editor and Problem Set Manager

One of the limitations of the IT105 Editor is that it is not portable to other networks. Many configuration parameters are unique and hard-coded for interoperability with our institution's infrastructure. Because of this, we have not released the IT105 Editor as an open-source project. Since the IT105 Editor is not portable beyond USMA, we recently changed our course's primary web programming application from the IT105 Editor to HTML-Kit. HTML-Kit is a freeware text-based web programming application. It is easily customizable and we provide our cadets with a version of HTML-Kit that is configured to optimize their experience in developing an XHTML-based web site employing Cascading Style Sheets. HTML-Kit is distributed as a Win32 executable package. Ultimately, we want our learners to become familiar with a web programming tool that can be used in other computing environments. Since all graduates go on to serve in the Army, they may have duties relating to maintaining pages on the World Wide Web or an enterprise intranet, therefore familiarity with a readily available freeware application like HTML-Kit is beneficial. Unlike our flowcharting tool, Raptor, and our lightweight IDE, our faculty make no contribution to HTML-Kit's source code. It is strictly third-part freeware that we take advantage of for instructional purposes.

Some course requirements precipitate the need for other commercial-off-the-shelf software that comes installed on cadet machines. Since Windows and Office are nearly ubiquitous on personal computing platforms in the Army and the Department of Defense, our cadets are served well to become familiar with the intermediate and advanced capabilities of these applications. There is no general desktop computing component of the core curriculum. Cadets must become familiar with these applications on their own or through freely available computer-based training.

In addition to all of the applications and tools mentioned above, we also develop and maintain a suite of Java-based tools to aid classroom instruction, assist cadets in completing assignments and facilitate grading and assessment efforts by our instructors. For instance, all cadets must develop a multiple-page XHTML-based web portal using at least one Cascading Style Sheet. This assignment has a number of requirements that demand the use of certain XHTML tag pairs and CSS rules. We have developed a web portal checker application that parses cadets' files that have been saved to a file server, searches for existence of the required tags and rules and provides page validation feedback to the learner and instructor. This tool helps guide the cadets to well-formed web pages that meet the requirements of the assignment and provides a repository of hyperlinks to all cadet pages that aid instructors in review and assessment. We have also developed an e-mail spoofing application that has been employed in classroom demonstrations about security and privacy. Several tools have been developed to allow instructors to retrieve assignment submissions from cadet file servers based on specified sub-strings, facilitate batch compilation and review, and aid in automated return of graded materials.

Herein we have discussed the broad array of languages, technologies, platforms and tools that are used by our students and faculty alike. Rather than relying on a monolithic approach to teaching Information Technology, we leverage the complexity that may be encountered when using such a diverse set of technologies and provide an opportunity to engage the varied learning styles that cadets bring to the classroom.

Assessment

In recent years, our assessment techniques have evolved from primarily out-of-class individual design and programming projects to in-class graded labs[9]. Despite this shift, we maintain a blend of assessment techniques that include both in-class and out-of-class work. About 50% of course points are associated with these in-class graded labs. A comprehensive final exam is worth an additional 30%. The remaining points are associated with out-of-class work and a hands-on soldering and design lab. All graded events for the course are structured to allow unrestricted access to the Internet, enterprise intranet and network resources, learner notes or previously completed work. More than just "open book", cadets can rely on voluminous resources to help them complete graded events. The only restriction is that they may not collaborate with or communicate with another individual or group during in-class graded events. Projects like the XHTML-based web portal, which are completed out-of-class, allow for collaboration and assistance, but learner interaction with others must be documented in a rigorous and clearly defined manner, attributing the work, ideas or cognition of others where appropriate. Proper documentation is an evaluated objective of this graded event.

Instructors are required to maintain open office hours. Since USMA's primary mission is concerned with educating cadets, faculty must remain responsive to cadet inquires throughout the day and to entertain requests for "additional instruction" cadets. Since the majority of course points are assessed during in-class labs, cadets are encouraged to seek answers to their questions in advance of the events and are advised as to how best organize and access the material that is made available to them for reference. Greater weight has been given to the comprehensive final exam in recent semesters. It has been worth as little as 22.5%, but in order to underscore the recurring foundational principles of IT found throughout the

course, we have chosen to emphasize the final more in recent semesters. Likewise, in order to recognize the differences of global learners as described by [4] from sequential learners, adequate assessment techniques must include systems-oriented overviews that demand the application of a holistic perspective. For our purposes, this is best achieved by a significantly weighted comprehensive final exam.

With no less than five major graded events each semester, cadets who struggle with one concept or problem context have several opportunities to overcome low scores and master the concepts over time. Along with labs and the final exam, there is also a semester exam covering basic computer principles.

Conclusion

The richness offered by the many different cadets, instructors, and experiences at the military academy contribute to the educational experience. IT105 seeks to embrace those differences and to focus the educational opportunities to the benefit of cadets of different ability levels, experience levels, learning styles, backgrounds and perspectives. The entire curriculum from in-class lessons to graded events seek to ensure that at least a portion of the material is presented or requested in a manner suitable to each learner's needs. The curriculum ensures that minimum standards are clear such at every instructor understands the common material while maintaining the freedom to leverage their individual skills and experiences. We have adopted varying technologies to enhance learning that go beyond diversity for diversity's sake. Our instructors have the tool set that best enables them to help learners achieve course goals. This is one of the first steps in the journey to transforming a range of individuals into the military leaders of the future.

The views expressed are those of the authors and do not reflect the official policy or position of the United States Military Academy, the Department of the Army, the Department of Defense or the United States Government.

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