Techniques for Supporting Diversity in a Core Information Technology Course[1]

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Abstract: This paper examines techniques for supporting diversity in an information technology (IT) course taken by all cadets at the United States Military Academy. The Department of Electrical Engineering and Computer Science (EECS) has historically had difficulty recruiting women and minorities into the computer science, electrical engineering, and information systems engineering. Part of this difficulty was a result of cadet experiences in IT105, Introduction to Information Technology and Computing. Cadets saw the course as difficult, technology centric, and irrelevant to the real world. As a result, we incorporated a number of changes into IT105 to make it more attractive to women and minorities. These techniques can be characterized as: appeal to a broader range of cadets; enhance communications with cadets; empower cadets; and, inspire cadets. We believe these techniques are applicable to other institutions trying to recruit women and minorities to engineering disciplines.

Background

The United States Military Academy first admitted women in 1976 and currently women represent approximately 15% of the Corps of Cadets [1]. Women do well at West Point and graduate at approximately the same rate as male cadets (79% male, 75% female). Minorities constitute approximately 20% of the Corps of Cadets and have higher representation than Army officer population. African-Americans are a notable exception with only 7.7% representation as opposed to an Army officer representation of 11.4%. Minorities enjoy similar success in graduation. Due to the requirements for acceptance and the reputation of the institution, cadets come from every state and represent a cross section of American society. US News and World Report ranks West Point as the 4th overall best engineering program without a doctorate and ranks the electrical engineering program as 8th [2].

[1] Opinions and views expressed in this paper are those of the author 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: Cadets Work to Build a Network and then Observe Network Protocols using a Network Sniffer

One would expect that the Department of Electrical Engineering and Computer Science (D/EECS) would have a significant representation of female cadets and cadets from other minorities that mirror the cadet population. This expectation as not been met and female and African-American representation within the department is quite low. In the latest class of thirty-seven computer science majors, there is only one female (3%) and two African-Americans (5%), four Asians (11%), and four Hispanics (11%). D/EECS is not alone in its difficulty in recruiting women and minorities to engineering and a recent ASEE Prism Magazine explored the difficulties of recruiting female and minority faculty and students [3]. Given these difficulties in recruiting, the D/EECS modified how it taught the required introductory information technology course so as to appeal to minorities. This paper presents the four approaches used to attract women and minorities to information technology.

The four approaches used to attract women and minorities are: appeal to a broader range of cadets; enhance communications with cadets, empower cadets, and inspire cadets. Each of these approaches are discussed below.

Appeal to a Broader Range of Cadets

To attract more cadets to information technology, we must appeal to a broader range of cadets and make those cadets feel comfortable manipulating technology. Certain cadet enter West Point convinced they will be computer scientists, electrical engineers, and information technologists. These cadets are enthusiasts and need no encouragement. Other cadets have predetermined their major and no amount of encouragement will dissuade them from the major that they have a strong interest and/or talent in. Some cadets enter college without a strong predetermination for a major. These cadets are often unfamiliar with or lack confidence with information technology. Women and minorities are found in this group at higher percentages than in the enthusiast group and are the principal targets of recruitment. To appeal to these cadets, we implemented the following procedures to appeal to a broader range of cadets:

1. **Advertise:** Built an entry pictorial for the faculty offices of the introductory information technology course with hundreds of smiling cadets working on various aspects of the course trying to convey that the course is more about cadets (all kinds of cadets) than technology. The message is anyone can succeed in engineering disciplines. In addition to

the large pictorial, we added motivational images that have a mix of females and minorities succeeding in the Army using technology.

2. **Address Tokenism**: Tokenism occurs when a individual is viewed as representative of a group because of limited members of the group within the class. For example, if there is a single female within a class, she becomes the voice of all females in the class. We addressed tokenism by grouping women so there are four or more in each section of eighteen cadets. This led to some sections not having any women but the overall result was to make women feel more comfortable in the classroom. This practice has spread to other courses in the department due to its liberating effect on women.

3. **Address Geekism through Narratives and Problem-Solving**: This deemphasizes technology for technology sake (geekism) which is unappealing to all but enthusiasts. Non-enthusiasts are interested in solving real world problems and helping people. We addressed geekism by linking the assignments together so that they tell a story. For example, a series of programming assignments examine providing medical treatment. The initial assignment addresses simple programs that provide prescreening data and data conversion. The second assignment examines using that data to diagnose childhood diseases while the third assignment employs a robot to deliver medicine to patients in a small room. The final projects adds minefields and a more open-ended scenario that challenges the cadets to solve general as opposed to specific problems. These types of problem solving appeal to females and minorities more so than solving problems for technology's sake.

   Instructors focus on the problem-solving aspect of the course and deemphasize programming as not the primary purpose of the course but instead a tool for problem solving. In fact, the course decoupled the two ideas so that problem solving and problem decomposition were a separate module from programming. The use of narratives focused on open-ended, real world problems with multiple, equally valid solutions appeals to women and minorities [4].

4. **Reduce Workload and Pace**: The course reduced the number of labs to focus on the important components of the course: information technology, sensors, and problem-solving with programming. This reduces the workload on cadets to counter the prevailing cadet opinion that D/EECS overworks and under-rewards its cadets. It also reduces the workload on instructors so they have more time to interact with cadets. This interaction is critical for students with low confidence in their ability to manipulate information technology. Woman and minorities often have low confidence in their abilities despite being quite capable.

5. **Build Confidence**: A course revision moved from the individual lesson to a modular approach that covered fewer technologies but to a greater depth. This builds confidence and supports communication of expectations. We also scheduled the modules moving from the familiar to the unfamiliar so as to build confidence within the cadets and convince them that they can succeed information technology. For many women and minorities, the most important lesson they learn in the course is that not only can they do

information technology, they are very good with IT. Finally we restructured the lesson objectives (see below) so that there are more hands-on, in-class exercises. Less lecture and more doing leads to more interesting and relevant classes. Being able to do something in the real world build confidence.

By advertising, addressing tokenism, minimizing geekism, using narratives to focus on problem solving, reducing workload and pace, and building confidence, we attempted to make information technology appealing to a broader range of cadets.

Enhance Communications with Cadets

Key to recruiting women and minorities is enhancing communications with cadets so that we know more about the cadets and understand the individual strengths and weaknesses they bring to the classroom. Class sizes at West Point are typically eighteen cadets per section which allows for the instructor to know and form a mentoring relationship with their cadets. We also need to communicate clearly our expectations so that there is not a disconnect between instructor and student expectations in the course. Our hypothesis is that better communications with students will attract women and minorities. The mechanisms we implemented were:

1. **Learn more about the cadet.** We used two principal mechanisms to learn more about the cadet: a web exercise and a learning style assessment. The introductory IT course has always had a web exercise where the cadets create a website that provides information on who they were before they entered West Point, what they are doing at West Point now, and what they hope to be doing twenty years from now. We moved this assignment early in the semester so that the instructors learn more about their cadets to facilitate a more personal relationship. We also asked the cadets to indicate their prospective major so we could determine what our majors our cadets were contemplating as they entered the Academy. By knowing more about our students, we can tailor cadet learning experiences so that they are more personal.

   We also built a learning styles assessment based on the Felder Learning Model so that cadets can determine what type of learner they are and what type of teacher they have [5]. The intent is to facilitate better communications and suggest coping strategies when there is a significant mismatch between instructor and cadet. A secondary effect is to illustrate to the cadets how technology can be used effectively to learn more about yourself and help others. This system will be used in future versions of the course website to support adaptive interfaces that are tailored to the individual user.

2. **Communications of Expectations**. Lesson objectives are very important for constructing a course and communicating expectations. We divided the lesson objectives into out-of-class and in-class objectives, and, recast them using Bloom's taxonomy to better communicate our expectations so that there is not a disconnect between course objectives, class presentations, and course assessment [6]. This should support better cadet performance, better communications, and encourage cadet confidence in their ability to use and manipulate information technology. The out of class lesson objectives encourage cadet preparation for class which is critical to building cadet confidence. We

have also rechecked our lesson objectives to ensure they are concise, consistent, and constructive to support a logical progression through the course. Being explicit about course expectations allows cadets to be specific in communicating what topics and concepts they do not understand and equally importantly, to identify those topics that deeply interest them.

The course instructors also built an evaluation and self-assessment system based on the lesson objectives and populated it with almost 900 questions. Each question is related to a lesson objective and has customized feedback so that cadets can asses their preparation for class and understanding of course material. The system also allows cadets see the type and difficulty of questions by lesson objective that they will encounter on their evaluations. This enhances communications of expectations and empowers cadets.

By learning more about cadets and being explicit in our delineation of expectations, we hope to communicate better with our cadets and be able to tailor learning experiences based on what we learn from that dialog. Through better communications, we will come to understand the different needs, strengths, and weaknesses of women and minorities and tailor classroom experiences that exploit their diversity.

Empower Cadets

Convincing minorities that they have the talent to make engineering their major includes empowering they to solve their own problems with technology instead of having to rely on their instructor for additional instruction. We used two approaches to empower cadets with regards to programming and evaluation.

1. **Empower Cadets with Programming**. Novice programmers tend to make the same mistakes as they learn to program and then spend hours trying to debug a simple error due to incomprehensible error messages. This leads to cadet frustration and a shift away from problem solving to forcing the program to compile. We built the Gauntlet system which finds common cadet programming mistakes (syntax and semantic) and provides feedback that the cadet can understand so that cadets can fix their own mistakes instead of having to call the instructor. Gauntlet works as a preprocessor that generates error messages. The error messages are written in a language that the cadets can understand and can immediately act on to solve their immediate problem. Gauntlet is built into the course editor which supports HTML and Java so that cadets only have to learn one editor in the course. Gauntlet allows cadets to solve their our problems without an instructor thus building confidence in their ability to do IT. It also allows cadets to focus more on problem-solving and less on syntax which appeals to a wider range of cadets.

2. **Empowering Cadets with Evaluations**. As previously discussed, we built an extensive self-assessment system that not only improves communications with cadets about expectations, it empowers cadets to assess their strengths and weaknesses related to the course and then self-direct and prioritize their efforts. The student is in control instead of the instructor and there is a direct correlation between preparation and success.

Inspire Cadets

Inspiring cadets provides opportunities for instructors to convey the love we have for our disciplines.

1. **Role Models**. One of the criteria for determining who is teaching in the introductory information technology course is providing appropriate role models. Providing a diverse group of faculty members allow cadets to identify with role models. It also reinforces that everyone can be successful in our disciplines.

2. **Exploratory Material**. The course added exploratory sections to all lessons to encourage the best and the brightest cadets to go beyond the course requirements. For those cadets, we provide an opportunity to explore material that will not be tested but extends the course material. Those cadets not interested in technology for technology's sake but are interested in the application of technology to solve problems revel in exploratory material.

3. **Extra Credit**. Similar to exploratory material, extra credit was added to all projects to encourage our best cadets to stretch their capabilities. This allows cadets to stretch their capabilities and select areas to research and learn in greater depth.

4. **Inspirational Quotes**. One of the questions that cadet often ask is why are we doing a particular module. To answer this question and provide real-world relevance, we build a quotes section to course web pages that automatically rotates through inspirational quotes. The quotes come from current cadets, recently graduated cadets, and current academic, military, and industrial leaders.

Summary

This paper has briefly addressed mechanisms employed by the Department of Electrical Engineering and Computer Science to support diversity in a core information technology course. Our approach focuses on appealing to a broader range of cadets; enhanced communications with cadets; empowering cadets; and, inspiring cadets. Our results in the classroom have been positive and cadet like the change in approach. Time will validate the effectiveness of the approach.

References

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