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Back to the classroom – Lessons and strategies

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EDITOR'S NOTES

I'm confident you will enjoy the array of articles we have for you in this Fall issue of *Mathematica Militaris*. We have gathered ideas from the service academies that address some key issues that deal with various lessons learned and successful strategies in the classroom. The common thread throughout these papers – we never stop looking for ways to improve.

The first article is by Major Dave Knellinger. Over the past couple years MAJ Knellinger noticed that the cadets at West Point are confronted with several similar but different problem solving formats. He presents a universal problem solving format that has great utility while it remains understandably simple.

First Lieutenant Joy Kaczor's article presents her successful strategies to leverage the use of the internet into her Calculus course at the United States Air Force Academy. LT Kaczor discusses how their math department dealt with the unique concerns that come with a format that uses non-traditional multimedia resources.

Next, Dr. Kenneth E. Siegenthaler from the USAFA Department of Astronautics gives us a great article on how a class called *Mathematical Physics* prepares their students for graduate studies. Appropriately named "Combat Ready for Graduate School," his paper informs the reader how they strike a balance between a text with the necessary rigorous theory and a text with a more understandable and applied approach.

Major Bill Crowley and Lieutenant Colonel Tyge Rugenstein author the next paper that describes the monumental task of implementing a wireless network in the Department of Mathematical Sciences at the United States Military Academy. Such a network does well to leverage the use of the laptops issued to the new cadets. They discuss both the technical aspects of the network as well as several classroom issues such as instructional technique and assessment.

In the next article Captain Jeff Havlicek from the Department of Mathematical Sciences at the United States Air Force Academy focuses on several key math education issues. A key issue is the necessity for students to learn from their mistakes and demonstrate their mastery in successive exams and projects. I identified several techniques from his paper that I am going to implement in my classroom.

The final paper co-authored by Lieutenant Colonel Mike Huber and Major Dave Smith describes how they have revitalized the "word problem". Their *Calculus I and Introduction to Differential Equations* course no longer has the typical midterm exams. Instead the students are assessed by six well designed "modeling and Inquiry Problems". They discuss the philosophy behind their bold move and also provide some detail regarding the structure of the problems and their assessment process.

As you read through the contributed papers in this issue, I hope you are inspired to share your own ideas, techniques and strategies with your cohorts. Please consider sending your own article to us for our next issue of *Mathematica Militaris*, and please visit our website to peruse the past issues at the following address: http://www.dean.usma.edu/math/pubs/mathmil/ .

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Solving the "Little Problems" in Life

Major Dave Knellinger, USMA,
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Introduction:

Our role as educators is to prepare our students to be able to deal with complex problems that occur in real life. We are successful if our students are able to use what was taught in the classroom in a new situation that they experience firsthand. Our structuring of some of our problems may actually hinder this goal. Some demand "the 4 step process" or the "7 steps to solve this problem" from our students, and penalize them if they don't conform. Some use these lockstep methods because someone (the teacher, the professor, the author, etc.) believes that this is the best way to solve a certain class of problems. What this does is create "stovepipes" or "cookie cutters" of problem solving patterns within the student. Students will use different "cookie cutters" for classes taught by a single department, since some instructors believe their way is the best way. As students branch out to different departments, the number of lockstep methods increase. You can only use certain steps for mathematical classes, others for chemistry classes, and so on. Students are not able to apply a mathematics method for a physics problem, since they are two different subjects, they must use two different systems.

However, we do not need to fill the students full of "cookie cutter" algorithms. We can create a few, robust problem solving processes that students can take out of the individual classrooms and use in their everyday life. We will show particular models that we currently use in Probability and Statistics, Discrete Dynamical Systems (DDS) and Calculus courses; generalize them so that the resulting process can be used in a variety of applications and then show how this process, not algorithm, can be used in both non-mathematical courses and real life. Finally, we will ask the question, "How do we structure our classes so that the students will be comfortable with this new problem solving tool?"

Processes in Mathematical Courses:

During Probability and Statistics, a specific "4 step process" is often used to solve probability problems. This process is:

1. Define the Random Variable
2. State the Specific Distribution
3. Write the Probability Statement
4. Solve

These steps are very course specific. The first three steps use probability-specific words. At first glance, this looks like a stovepipe-type process. A student can't use any of the four steps for anything other than a probability course.

Let us now look at another core mathematical course that is taught at the undergraduate level. As with Probability and Statistics, these courses have their own processes to solve problems. Consider this process that is often used for Discrete Dynamical Systems:

1. Define your Variables
2. State Initial Conditions
3. Write the Recursion Relationship
4. Solve

While this process also has four steps, it uses DDS language (initial conditions, recursion relationship). Again, the language makes this four-step process course specific. The two processes look different, so we tend to believe that they must be different.

Finally, let us look at the traditional basic mathematical course, Calculus. One relatively common four-step problem solving process is:

1. Define your Variables
2. State Domain
3. Write integral
4. Solve

This process is similar to the DDS process, but requires the student to understand integrals and functions, while the DDS process uses recursion relationships. Again, because we are in a different course, we have a different process.

In each of these problem-solving processes, the fourth step is *Solve*. While this looks like a generic step, applicable for all courses, the mathematics for this step can be very course specific. Solving for a probability problem may consist proofread of referencing a chart, either on paper or in a software package, for a particular number. Solving a DDS problem may consist of iterating the recursive relation a pre-determined number of times. Finally, solving a Calculus problem may require the student to recall a number of integration rules, manipulate the function in question to create another function, and then substitute in the values of the endpoints of the domain.

An Analysis:

Let us look at the three procedures closer as they are summarized in Figure 1 below.

Step	Probability Procedure	DDS Procedure	Calculus Procedure
1	Define the Random Variable	Define your Variables	Define your Variables
2	State the Specific Distribution	State Initial Conditions	State Domain
3	Write the Probability Statement	Write the Recursion Relationship	Write Integral
4	Solve	Solve	Solve

Figure 1.

All three start out by asking the student to *define a variable*. In each course the variables have certain unique characteristics. In Probability and Statistics, a variable may follow a defined distribution with parameters, while in DDS the variable is a function of what step before. The student, who watches the results to see the change in the solution, can manipulate the variables in all three cases.

The next step asks the student to *write down information* about the object that they defined. In all cases we go from a general type of situation (family of variables), to the very unique situation (specific variable) that the problem presents. Notice that the information may have been given in the problem (facts) or may be omitted, forcing the reader to create numbers (assumptions) in order to solve the problem.

The third step asks the student to *Translate the Problem* (usually given in words) into a mathematical procedure that can solve the problem. For a basic mathematics course, this is relatively easy. During the semester, there are but a very few procedures taught. An instructor may consider the translation step the critical step, since for some picking the same procedure that the instructor chose implies that the student learned the "right" technique.

The final step *Solve,* is what some teachers will access with the most weight. This step uses the techniques that were discussed in class to come up with a solution. Teachers consider this to be either right or wrong. Either the student got the same solution that the instructor did, and receives full credit, or the student came up with a different one, which may earn them partial credit.

A New Problem Solving Process:

We can reduce students' memorizing a litany of course-dependant algorithms by using a common problem solving process. This process may look like:

Step 1: Define what you are looking at.
Step 2: Write down information and assumptions.
Step 3: Translate the problem into a domain so you can solve with a known technique.
Step 4: Solve.

Step 1 asks what are we looking at? In class, this is usually easy, as this question is written down. We often give the students this step, since there is a lot of art in defining a problem. However, outside the classroom, this is typically the hardest step, as most real-world problems are ill-defined. Students need a lot of practice to be comfortable with this step.

Step 2 requires the student to gather information about the problem. This could be information from the question itself, from a reference sheet or notes page, or from a different source entirely. In the real world, this step would include researching the problem itself, and possibly making assumptions to limit the scope of the problem.

Step 3 calls for the student to translate the problem. The problem is usually written down and handed to the students as an out of class assignment. This step asks the students to shape the problem into a procedure known to the student, in preparation for solving it. Step 3 and Step 1 are the two hardest steps to do in a real world problem. With an ill-defined problem, knowing what procedure or procedures will solve a problem is almost as hard as defining the problem itself.

In Step 4 the student must apply a technique to the translated problem. This typically receives a lot of attention from the teachers. However, the amount of technology that is available to the student minimizes the amount of hand manipulation needed to complete this step. There are calculators that can compute the cumulative density function for a normal curve, iterate a DDS, and compute definite and indefinite integrals. Techniques are rapidly becoming an exercise in learning about the available software or electronic devices as efficient alternatives to using pencil and paper.

Structuring Classes

So as teachers, how do we get our students to be confident enough in their abilities so that they can accomplish a goal of this magnitude? A starting point may be to look at the "stovepipe" learning presented to the student. Instead of constraining them to a particular set of algorithmic steps to solve a class of problems, we could offer a general system for solving problems such as we propose in this article and let them learn how to work the different classes of problems.

Also if we give the students problems that require drawing upon different techniques, we force them out of the stovepipe mentality. Researching an ill-defined problem that a mathematical teacher hands out may allow the creativity traditionally associated with a humanities course to break through when students understand this general problem-solving approach we offer. Using a problem solving procedure in a humanities course may allow the student to use a support structure in qualitative class and vice-versa.

Our success as educators is not a number or a class profile. It is an individual that several years from now feels that they have the ability to solve ill-defined and rapidly changing problems. If we give our students a few basic multi-use tools and show them how they work in a variety of circumstances now, our students can solve problems that will confront them in the future.

Multimedia Learning in the Internet Age

First Lieutenant Joy M. Kaczor, USAFA, Department of Mathematical Sciences

I was very fortunate to attend the New York University Faculty Research Network seminar about Instructional Design for the World Wide Web in June 2002. What I observed is that while many of us use or would like to use the Internet in our courses, most of us have not considered all the aspects of such a task, including the effects on student learning, the variety of technology available, and the process involved. This article will hopefully provide you with some insight into each of these facets.

Multimedia learning is not a new concept. However, how we as instructors implement multimedia learning into our courses has changed over the years. The advancements of technology and the proliferation of the Internet provide many avenues for instructors to pursue. Furthermore, the uses of technology are often more prevalent and more intuitive to students in math and science courses. Nonetheless, one of the limitations is the instructor's ability to effectively incorporate technology into the course.

Multimedia Learning

Multimedia learning can be described as presenting instructional materials in a variety of forms, including visual via animations or illustrations, and verbal via narration or text. Much research has been conducted on the effects of multimedia learning. One study by Richard Mayer from the Department of Psychology at the University of California, analyzes the conditions under which multimedia environments promote problem-solving of scientific and mathematical principles. Richard Mayer's research results indicate that students can better interpret "mathematical or scientific explanations when they are able to hold relevant visual and verbal representations in working memory at the same time." [3] This means that students were better able to internalize the concepts when they were provided simultaneously via visual and verbal representations. As instructors of mathematics it is very important for us to consider these findings and how we can better provide both visual and verbal representations of mathematical concepts to our students. Integrating multimedia learning into a course can be easily done with the use of computers and the Internet.

Computer- and Web-based Learning Environments

In another study, Mayer indicates that it is important to distinguish between delivery media, presentation modes, and sensory modalities.[4] The Internet enables instructors to tap into various presentation modes and sensory modalities, including, but not limited to, text, narration, PowerPoint slides, video, interactive java applets, and on-line assessment. However, these capabilities are not limited to use via the Internet. Moreover, there are several advantages and disadvantages that the Internet provides. Some social advantages include group collaboration, interactive learning, some anonymity, and different modes of interactivity. The technology advantages are vast; however, the ability for students to have a common source to retrieve and post course information, as well as to have access to hypertext links and global resources are very important to effective use of the Internet in a course. The overall benefits include the instructor's ability to customize web site content based on student needs and the ability to control the delivery methods. Internet technology can also enable instructors to provide students with immediate responses and feedback. Furthermore, most students are comfortable with technology and can easily immerse into the subject matter. The Pew Internet and American Life Project completed in September 2002 states that "20% of today's college students began using computers between the ages of 5 and 8."[1] The study goes on to say that all of today's college students were using computers by the time they were between 16 and 18 years of ages, "and the Internet was a commonplace in the world in which they lived."[1] The report also provided additional statistics that concluded that 86% of college students have been online, compared to 59% of the general public. Most importantly, the study found that, "79% of college students agree that the Internet use has had a positive impact on the college academic experience."[1]

Conversely, there are also several obvious disadvantages of using the Internet, most importantly connectivity issues and software and hardware requirements. The previously mentioned study also states that 85% of college students own their own computers.[1] Fortunately, 100% of all students at the USAF Academy have computers and approximately 60% have laptops.[5] However, the requirement for students to have special software or non-typical hardware may prohibit students from being able to effectively use the Internet. Thus, instructors should consider the number of students that have computers and the types of software students have at their university when incorporating technology into a course.

Multimedia Learning in Calculus I

The Calculus I course at the USAF Academy (USAFA) currently incorporates all of the previously mentioned presentation modes via the Internet and via laptops in the classroom. As one of the instructors for the course, I feel that we are very fortunate to have the technology available that enables us to provide our students with a variety of learning modalities. We have a course website, hosted on the USAFA intranet, which provides students with access to all of the course lessons, interactive java applets that allow them to manipulate equations and graphs, the course textbook, and various other helpful documents. Additionally, the Calculus I course uses Addison-Wesley's Course Compass web site, on the Internet, which works hand-in-hand with the textbook. The Course Compass web site uses Blackboard technology and allows the instructor to customize the site for their course. The site provides the entire textbook on-line and separates it by section. There are videos, tutorials, and practice problems for each section, as well as chapter tests. Instructors are able to post on-line homework, and other on-line assessments such as preflights, quizzes and tests. This tool has proven to be very helpful for both the students and the instructors. It can generate algorithmically driven assessments, thus providing each student with a unique assignment. It grades the assignment and creates a study plan for the student based on his or her results. Most importantly is that, it enables students to practice as much as they need to with a variety of tools—video and tutorials—available to them for guidance. Of course, we have to be flexible with online assignments. We have had a few occasions where the assignment was not viewable to the students due to technical problems on the server end. However, flexibility and communication were the key to ensuring that the students were able complete the assignment.

In addition to the Course Compass site, the course incorporates the use of laptop computers in the classroom—all first year students have laptops. Students use the laptops in class to view their textbook, use any of the 30+ java applets, use MS Excel, and to use Mathematica. The classrooms also have wireless internet connectivity, which enables instructors incorporate this capability into their lessons. The use of technology is an integral part of the course and helps the instructor present a multimedia learning environment for the students by providing information as a visual representation of what the instructor is explaining verbally.

Instructional Design

Prior to developing a course web site, it is important to consider the instructional design process. "Briggs, Gustafson, and Tillman (1991) define instructional design as 'a systematical approach to creating effective instruction'" [2] They continue to point out that instructional design 'ensures congruence between objectives, instruction, and evaluation.'[2] Additionally, Briggs, Gustafson, and Tillman provide six principles of instructional design:

1. Objectives, instruction, and evaluation are related and congruent, and each affects the other.
2. Components must be related.
3. Process of instructional design must be systematic but flexible to allow for changes and cyclical development.
4. Instructional design should be research based.
5. [Instructional design] must be open to testing and improvement.
6. Compare final design to alternative or at least to the objectives. [2]

In addition to the afore mentioned principles, instructional design has several phases, which were adapted from the system development life cycle. A generic model consists of five phases: analysis, design, development, implementation, and evaluation. The design phase can be divided into three sub-phases: informational design, interaction design, and information architecture design. During the informational design phase, the instructor needs to define the type of data and the format that the information should be provided in. The interaction design phase is used to specify the form of user interaction, the features provided, and design decisions on all levels of interaction—conceptual, semantic, syntactic, and lexical. Finally, the conceptual design of the web site, its structure and general functionality are defined in the information architecture design phase.

The entire process can be time consuming and should not be done solely by the instructor(s). Individuals with experience in instructional and web design should be involved in the process. However, Mathew and Dohery-Poirier point out that simplicity is the key to creating instructional web pages. They explain that attempting to use many special effects may not be necessary during the initial design of the web site and will probably not be beneficial to the developer's time nor to the students. It is very important to create a clear and defined structure with easy access to the instructional materials. They state that the most important consideration is the content—without it, the web site is useless to the students.[2]

Evaluation

A course web site, such as the Course Compass site used in the USAFA Calculus I course, can very easily be used to evaluate students' progress, key principle comprehension, and even course evaluation. Evaluation can come in many forms—electronic portfolios, on-line diagnostic tests, and a variety of other methods that instructors can use to evaluate a student's needs and progress. A needs assessment questionnaire can be administered at the start of the course to evaluate students' current level of understand of the subject matter and again at the end of the course to assess the student's knowledge of the objectives. Instructors can also use on-line preflights, short pre-lesson assessments, to provide just-in-time teaching based on students' responses. Finally, evaluations should be both formative—conducted throughout the process, and summarative—conducted as a final evaluation.

The USAFA Calculus I course provided an on-line survey for students that allowed them to provide feedback about the course and the use of technology in the course. Approximately 50% of the students (180) in the course responded to the survey. Students rated their aptitude for technical subjects as 3.63 on a 5.0 scale, indicating medium to medium high aptitude. They also rated the internal course web site at 2.96, as somewhat difficult to somewhat easy to use. Ironically enough, they rated the helpfulness of the use of laptops in class as 1.97, signifying hindered learning to hindered learning a little. Of course this caused some concern amongst the faculty. However, what we determined is that the survey was administered early on in the course and the only technology used up to that point was Excel. Many of the students, to our surprise, had never used Excel before and thus had become very frustrated with trying to learn both Excel and the concepts during the first few weeks of class. The lesson to be learned here is that when introducing the use of technology in the course, even something as simple as Excel, the instructor should consider the audience and any additional learning curve of learning how to use the technology.

Conclusion

Research results indicate that multimedia learning enhances student comprehension of scientific and mathematical principles when they are provided simultaneously as visual and verbal representations. A multimedia learning environment can be created with the use of computers and

Internet technology, as in the example of the USAFA Calculus I course. Whether it is through the use of computers in the classroom or by incorporating a course web site, technology can be used to the present material in a variety of modes. While a course web site can be very beneficial to both the students and the instructor(s), it can also be a daunting task to create. The developer(s) should use the principles of instructional design and the five phase approach as a guideline for developing and incorporating the web site into the course. Finally, course and student evaluation should occur throughout the course as well as at the end of the course, with continuous evaluation of the effectiveness of the technology being used.

References:

1. Jones, Stephen, et al (September 2002). "The Internet Goes to College." Pew Internet and American Life Project. URL: http://www.pewinternet.org.

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3. Mayer, Richard (1997). "Multimedia Learning: Are We Asking the Right Questions?" *Educational Psychologist*, 32(1), 1-19.

4. Mayer, Richard (April 1999). "When Multimedia Works: Designing Multimedia for Meaningful Learning." Paper presented at the annual meeting of American Educational Research Association, San Diego.

5. Personal Communication with Larry Bryant, Director of Academic Computing, USAF Academy, November 4, 2002.

Combat Ready for Graduate School?

Dr. Kenneth E. Siegenthaler, USAFA, Department of Astronautics

Mathematics 470, Mathematical Physics, is a course taught at the United States Air Force Academy intended for students who will pursue graduate studies in physics and applied mathematics. This course is taught on demand as a spring semester course intended for first classmen (seniors), and second classmen (juniors), who intend to go to graduate school. Various instructors have taught this course, from the Mathematical Sciences Department or Physics Department over the last 20-plus years. The class is usually small, four to ten students, and is taught on average of every other year.

Text Selection

The texts used in the past have oscillated between *Mathematical Methods for Physicists* by George B. Arfken and Hans J. Weber and *Mathematical Methods in the Physical Sciences* by Mary L. Boas. Arfken is wider in scope and more theoretical. Boas is limited in the material covered, but is much more understandable for undergraduate students. In the past, when Arfken was used the students have done poorly as a group and have complained that the book was extremely difficult to understand. When Boas has been used, the instructors have commented that they had to extensively supplement the material to bring the course up to the "proper" level. After reviewing these comments by cadets and instructors from past courses and reviewing Arfken and Boas, it was decided to use both texts for the course. The reasoning was that Arfken is at the level required as a mathematical reference in graduate studies in physics and applied mathematics. Arfken also has a much broader coverage of applied mathematical subjects employed in graduate courses. There is no doubt that Arfken is the type of mathematical reference book the graduate student or practicing researcher would want on their shelf. It is important that the student be comfortable with Arfken. Therefore the philosophy was to use Boas to introduce a new section and then ease the students into Arfken where the same material was covered at graduate level.

Course Content and Philosophy

This course could easily be a four semester course in order to cover the possible applied mathematical material used in graduate physics and applied mathematics courses. The decision was made to cover areas that other USAFA math courses do not cover or did not cover in sufficient detail. The idea being that these areas supplement and complement the mathematical program as a whole. The areas covered were series solutions of differential equations, complex variables, calculus of variations, partial differential equations and Green's functions.

The overall philosophy of this course was to mathematically prepare the students for graduate courses in physics and applied mathematics. One of the main objectives was to raise their mathematical knowledge/comfort level to the graduate level of Arfken. Since some of the students will have Air Force assignments before being sent to graduate school, it is important that they have a reference that will get them up to speed rapidly when necessary to refresh their mathematical background.

Class notes tend to get lost and minds tend to atrophy. Therefore, all examinations were open book, but not open notes. On those exams, students were allowed to use their textbooks and anything they have written in them, but not separate notes. This encouraged students to annotate in their textbooks all kinds of hints and other aids to understanding and applying the material in the text. They were also allowed to have worked out examples of particularly important problems on blank pages in the text. This concept encouraged the student to physically spend more time in the text. It also ensured students keep their textbooks as a reference for graduate school. The importance of building a personal professional library was continually emphasized during the course.

As a part of the special projects assignments, each student taught a lesson on a subject using mathematics related to the course material. All of their lessons were excellent in both the level of the mathematical theory and the applicability to our course.

Student Composition

The student composition of this class included students majoring in mathematics, physics, astronautics, and electrical engineering. Some students were double majors. One student was a double major in astronautics and mathematics and a minor in Russian.

Results

Because of all the additional pressures on cadets in their spring semester before graduation, this course had a reputation as a course to avoid if possible. When the instructor demanded high-level performance from Arfken, the cadets hated it. When Boas was used the instructors felt the students were not as well prepared for graduate courses.

The combination of using both *Mathematical Methods for Physicists* and *Mathematical Methods in the Physical Sciences* as textbooks in the course, and open book examinations, resulted in an excellent course from both the student's and instructor's point of view. As the instructor I felt all of the students in the class were well prepared for graduate school. Student reactions to the course were expressed in student evaluations. One of the quotes from these student evaluations stated, "Now that I have completed all my finals, and consequently my education at the United States Air Force Academy, I can honestly look back and reflect upon my entire academic experience. Your Math 470 class was absolutely the best class I have taken." This quote was by an electrical engineering major. Another quote, "I actually looked forward to attending class on every lesson! On several occasions, I even called home to tell my parents about the math I was learning…" Not the usual comment that a Mathematics Department receives from a cadet on an advanced mathematics course.

We are going to teach Math 470 in the Spring 2003 semester. It will be interesting to discover if we have found the right content to satisfy both students and instructors, or whether it just happened to be a one-semester event.

Laptops and the Wireless Network in the Classroom: Problems and Solutions

Major William L. Crowley and Lieutenant Colonel Edgar K. Rugenstein, USMA, Department of Mathematical Sciences

In 1986, the United States Military Academy implemented a policy that required all first year students to purchase standard desktop computers. These computers provided a standard platform with consistent software, allowing instructors the ability to assign homework and projects knowing the capability of the students' systems. Since that year, cadets have continued to purchase a "cadet issue" computer, providing a corps wide standard for computing capability. In 2002, the Academy changed the policy requiring first year students to purchase laptop computers. Given the portability of the laptop, West Point launched a pilot program, supported by 8 instructors from the Department of Mathematical Sciences, to test the value of establishing a wireless network in the classroom.

The laptop computers issued to the students initially did not contain the necessary software to support the wireless network. Therefore, the first step in the pilot program required the instructors and students to complete the installation of the wireless card driver and the wireless fire wall software in the classroom. This process initially took the instructors approximately 60 minutes to load a class of 18 students, but once they discovered and overcame the recurring common problems, the software installation took only 20 minutes per class. After all students were loaded and online, instructors reviewed and tested proper boot-up and login procedures. At this time, it is imperative for the instructor to establish ground rules for using the wireless network while in class, including when a student may use the World Wide Web and send or receive e-mail.

After three months of testing, administrators of the pilot program discovered bugs in the wireless wall software. Instead of using valuable class time to complete a software upgrade, the Information and Educational Technology Division (IETD) created teams, with the support of the contractor providing the wireless wall software, which went to the student's room and executed the upgrade one-on one. In total, three teams of software specialists upgraded over 500 student computers in a four day period. Although this process was ultimately successful, it is not a technique the Academy will continue to use to upgrade software after the pilot program terminates. IETD must establish a procedure for performing software upgrades without the loss of class time and without the support of an outside contractor. These upgrades are critical, not only from the operational stand point of maintaining the most recent software, but to ensure the network and users remain in compliance with changing DOD standards for network security.

In order to maintain connectivity with the student laptops, both the student and instructor must be capable of performing basic trouble shooting. However, due to time constraints in the classroom, it is usually not convenient for the instructor to attempt to do so. After class, the instructor may attempt to solve the student's problem or may refer them to either the academic department's computer specialists or to the Academy help desk. Both sources maintain the necessary software and knowledge to troubleshoot and repair the students' laptops. Regardless of where the student receives assistant, if the student or instructor are unable to fix the problem quickly in class, the student will be required to share a computer with a fellow student or complete the lesson assignment using alternate means.

Perhaps a more responsive solution is to establish a mobile help cell located in the academic building capable of assisting instructors during class as problems arise. A call button would alert the cell of a problem and the team would respond and determine the appropriate level of maintenance, whether themselves, the department computer specialist, or the academy help desk. Mounting call buttons inside the classroom may seem somewhat excessive, but as the classroom becomes more and more technical, we must find ways of resolving problems rapidly, or the faculty and students will become frustrated and will not use the technology available.

The obvious benefit of the wireless network in the classroom is the immediate connectivity provided by the network. The network allows for easy sharing of documents between students and teacher. The instructors uses three methods throughout the semester, the first being a passive technique of sharing documents through a public folder. Each classroom at the Military Academy has a computer that supports daily instruction. Once the instructor establishes a public folder on this computer, which the students and instructor can map to using the computer's name, students can save and retrieve documents to and from the folder freely over the wireless network. This technique may prove useful for collaborative assignments, such as projects or labs. Another method of passing information from the instructor to the student is via a course or instructor webpage. Documents can be linked to by the student and saved onto their laptop or opened directly from the webpage. Finally, a more active method of sharing documents is through e-mail. An instructor can easily pass a quiz or worksheet to the students using a class distribution list. This allows for the electronic distribution of papers in the same fashion as hard copy, providing positive control over the document as it is distributed.

During the pilot program, instructors experimented with digital quizzes. As an exact replica of a paper quiz, digital quizzes are not very efficient or effective. The cadets are unable to input there answers quickly in a meaningful mathematical manner due to the cumbersomeness of writing equations and other technical expressions within a *MS Word* or *Excel* document. Many students found the in class computer quiz to be time consuming and not a fair assessment of their capabilities. However, the idea of having paperless quizzes is still very appealing.

In order to create effective digital quizzes, instructors must format them appropriately for the computer and the wireless network, possibly in a multiple choice format. This format is acceptable given the requirement to justify answers after each question. The difficulty in this is implementation. To fully take advantage of a computerized multiple choice quiz, instructors should write the quiz in a language like Active Server Pages (ASP) or Java Server Pages (JSP) in order to easily extract just the answers for grading and feedback. Of course, another alternative is to use the wireless network to administer less computationally intensive quizzes, such as quizzes or tests with an essay format. Regardless of the format of the examination, providing feedback to the student is paramount.

During the pilot program, most instructors attempted to provide hardcopy feedback to the students, requiring printing the completed quizzes. Since students did not feel constrained by a piece of paper during the quiz, they often used several spreadsheets to answer a single question. The end result was four or five times more paper than would have been expected using a traditional format. Since feedback is important, we must continue to seek solutions that provide easy, meaningful feedback to the student. An off-the-shelf editing software, or the editing capabilities of *MS Word* or *Excel*, may prove to be a useful tool for making comments directly onto the student's digital work.

A tremendous capability of the wireless network is the ability for the student to visualize mathematics by utilizing dynamic websites on the internet. For example, early in the semester, students studied recursive relationships using the Towers of Hanoi, a puzzle that requires the user to move a tower from one peg to another adhering to specific rules. However, rather than use an actual wooden puzzle, as we did in the past, students now go online to a Towers of Hanoi website and work the same puzzle in a virtual world. One benefit of the online puzzle is its portability. The student now returns to their room and continues the exploration, where as in the past, the investigation was limited to the classroom. The internet has a plethora of websites supported by applets and other visualization tools that support student investigation, and the wireless network now makes those tools available on every student's desk.

The future of the wireless network appears bright. Currently there are 802.11-b standard wireless overhead projectors; we anticipate it will not be long before we see the same for the 802.11-a standard network. This will allow for connectivity between either the instructor or student's laptop and the overhead projector. The instructor or student will have the capability of playing CD's, DVD's and, with an adapter, VCR's in the classroom. Additionally, they will have access to personal files, located on their own laptop computers, without having to map to remote drives. Once this occurs, and all instructors receive laptop computers, the Academy will have the opportunity to remove the classroom computers that currently support classroom instruction. Finally, the supporting wireless wall software contractor is developing classroom control software that will allow the instructor to monitor cadet computers and allow for the sharing of information across all computers in the room. Once this is accomplished, the Academy will have reached seamless connectivity, ultimately making each classroom a flexible computer lab fully supporting the integration of technology in the classroom.

Revision in Quantitative Courses: A Matter of Core Value

Captain Jeff Havlicek, USAF,
Department of Mathematical Sciences

> Imagine a military unit that tried as hard as they could to prepare for their first attempt and took no interest in improvement. There would be no operational exercises or Operational Readiness Inspections. Units would try to be as prepared as possible for the real war without practice. There would be no after-action reports to review lessons learned. Units would never attempt the same project a second time and would be uninterested in progress. Imagine preparing a letter for you boss and he notifies you of the typographical mistakes. He doesn't ask you to correct them saying he will use the letter as-is, typos and all, but that he is disappointed in your performance. Do these situations resemble our military? NO! We take pride in our work and we correct mistakes made.

What values are you including in your course syllabus? Your point system is indicative of what you value in the course. Are you accepting error-filled work without providing the opportunity for students to revise their work?

The focus of this article is to endorse student revision in the pursuit of excellence. In quantitative courses where skills and concepts are often ordered sequentially, prior mistakes are often magnified in subsequent student performance. I collected evidence that suggests that students were, on average, learning about 90% of the new material I assigned. However, they were not correcting their misconceptions or filling their missing gaps in knowledge. Therefore, students who score 90 percent on their first exam would receive an 81 percent on their second exam (.90 x .90), and a 72 percent on their third exam (.90 x .90 x .90). No matter how much I warned cadets of this relationship, they did not make the time to correct their mistakes.

This situation troubled me deeply until I determined that it was I, not the students, who had a solution. The students saw a new block of material with a looming exam and focused on where the new points were perceived to be attached. In their minds, there was no reward for correcting past mistakes. They missed the notion that they had no reasonable hope to learn advanced theories if they did not master the basics of the course. This was their error, but I had failed to provide appropriate incentives to encourage the positive behavior of correcting one's mistakes.

I propose a new method of grading—one that rewards the ability to master skills the second time around. Allow cadets to correct their exams or projects to earn partial credit. For example, let's suppose that I allow for one out of every four points corrected on an exam to be added to their exam grade. Suppose that a student earns an 86 percent on an exam. He has been given his exam back with error markings but no answers. He has one additional class to return the exam with corrections for possible additional points. If he corrected 12 of the 14 points missed, he earns an additional 3 points, raising his grade to an 89 percent.

I foresee four concerns. First, some might question the academic equity. Does the student who gets the problem right the first time earn his just reward? The student who earned a 98 percent from the very beginning is in far better shape than the student with the revised score of 89. Likewise, the student who earned an 88 percent on the exam has an opportunity to raise his grade higher than the student with the 84 (the 88 can be raised to a maximum of 91 while the 84 can be raised to a maximum of 90). Furthermore, I am rewarding the pursuit of excellence. I am rewarding cadet interest in the problems and their solutions as opposed to wasting instruction time quibbling over the value of their incorrect work. They have the chance to do it perfectly the second time around and show their mastery of the material.

Second, some might say that re-grading exams is time intensive for the instructor. Re-grading is far easier than an initial grade. You only recheck those items the student missed. Many errors, such as lack of units or an incorrect answer on a multiple choice problem are trivial to score. You will also save time from quibbling over partial credit since no answers will be given until after students have had a chance to correct their work. Also, if my hypothesis is correct, errors relating to previous material should decrease thus speeding up the act of initial grading of future exams. Time in class spent on reviewing previous material should reduce as the variance in understanding between the students with good and bad initial test scores reduces. Plus, the opportunity to focus students on a commitment to excellence should be worth a little extra of your time.

Third, a naysayer may claim it is unfair that students are allowed to use texts, notes, peers and instructors to correct their exams. I offer two rebuttals. First, most military jobs allow for the review of materials and the consultation of people to perform one's job. Second, this issue is simply a matter of swapping the collaboration policy from pure individual effort to resource-open joint work. Almost all course syllabi allow for both policies at some point in a semester.

Finally, someone might declare that averages will be too high for effective stratification of grades. It is true that this policy will "raise the bar" and allow us to come closer to meeting the core value "excellence in all we do." Higher education and military service expect nothing less.

The author would like to thank the educators at Aurora College in Colorado for their insight into the value of student revision.

Captain Havlicek is serving as an assistant professor of mathematical sciences at the USAF Academy in Colorado Springs, CO. He hopes to earn a Ph.D. sponsorship and continue in education or technical leadership in the USAF.

Return of the Word Problem

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As mathematics instructors, we always enjoy reading mathematical cartoons. One of our favorites is that Far Side cartoon that depicts the angel standing with a man at the Pearly Gates. The angel says,

> "Okay, now listen up. Nobody gets in here without answering the following question: A Train leaves Philadelphia at 1:00 PM. It's traveling at 65 miles per hour. Another train leaves Denver at 4:00… Say, you need some paper?"[1]

Many of us have had nightmares about the dreaded word problem in our own mathematics experiences. However, with the current emphasis on solving applied problems with calculus and differential equations, the word problem has re-appeared and is actually making a popular comeback.

The second core mathematics course at the United States Military Academy, MA104, is entitled, "Calculus I and an Introduction to Differential Equations." The three midterm exams, or written partial reviews (WPRs), from last semester have been replaced by six Modeling and Inquiry Problems, or MIPs. Each MIP is designed as a word problem that challenges the student to solve one applied problem. There are no more problems where the student must simply find a derivative or antiderivative. No more proofs of the Fundamental Theorem of Calculus. No more asking for the solution of a differential equation that a calculator can spit out. Now, students must model a problem, draw a diagram, define some variables, state what's given, make some assumptions, express relationships that tie together the variables, use techniques to solve the problem, and then discuss the solution back in the context of the original problem. A follow-on question usually exists, extending the student's perception in the problem, and that follow-on inquiry must also be discussed. This new approach combines modeling with solution methods, as well as writing in mathematics.

As stated earlier, there are six MIPs, dealing with six areas of calculus and differential equations: Related Rates, Optimization, Accumulation, Applications to Physics, Harmonic Motion, and Exponential Growth/Decay. A typical optimization MIP using single-variable calculus might be:

> Your company has been using a rectangular storage container with a volume of 10 m^3 to ship out their product. The containers have a square base and top. To support the weight of the product and to allow the containers to be stacked, the top and bottom are made of a stronger material that costs \$6 per square meter. The sides of the container are made of a material that costs \$4 per square meter. Design a container that will meet the 10 m^3 requirements while minimizing the cost.
>
> An employee came up with the idea to ship the product in containers with a volume of 5 m^3. Since the boxes will be holding less product, the material required

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[1] Taken from the cover of a *Far Side* greeting card entitled, "Math phobic's nightmare". Copyright by Gary Larson.

to construct them will not have to be as strong, so the containers will be less expensive to produce. If the company goes to the smaller container, the cost of the base and top is now only \$4 per square meter, but the cost of the sides is still \$4 per square meter. Should the company switch to smaller containers?

The assessment for each MIP covers three broad areas: Modeling the Situation, Determining a Solution, and Inquiries and Discussion. Students must go through the entire modeling process, to include making valid assumptions and stating which technique they will use to solve the problem. Emphasis is placed on modeling and on the discussion. The solution is obviously important, but not as important as briefing the solution back in the context of the problem. In this particular example, each student must solve two minimization problems, but he or she must also compare the two costs in relation to the original volumes. The second box is cheaper to produce, but two smaller boxes cost more than one larger box, even though the volumes are both 10 m^3. That is the point of the follow-on problem. We try to extend the student's textbook readings into a "what if?" scenario where some of the data changes.

Regarding grading, students are assessed using a scale of A – C – F – N. Each section of their work – Situation, Solution, Discussion – is broken into measurable pieces that are each graded for student understanding. A students receives N if no attempt at that part of the work is apparent. Thus, if student X submits a poorly-solved solution, he or she might receive an F, showing a lack of understanding; however, a partial credit is given. If student Y does not submit a solution, he or she receives an N, indicating no credit. A 50% F grade is better than a 0% N grade. The student receives feedback for the three main sections, but not for each individual piece. The instructor totals up all points and gives an overall grade, which generally is a weighted average of the three section grades.

Feedback from students is generally positive. MIPs are currently given in a computer lab, where students have access to a computer algebra system (*Mathematica* is being used at USMA) and a calculator. Next semester, each student will have his or her own laptop, so MIPs may be given in any classroom.

Another difference with this approach from previous semesters is the new syllabus. Each lesson is geared to solving a group of applied problems. Implicit differentiation is introduced as students try to solve related rates problems. Maximum/minimum ideas are learned while solving optimization problems. Eigenvalue/eigenvector and matrix algebra skills are introduced as students try to solve harmonic oscillation problems. An entire week is spent on solving Physics-related problems, to include Work, Hydrostatic Force, Pumping Fluids, etc. This week culminates in another MIP. A possible drawback is that only one of each type of problem can be assessed. However, this drawback existed with the previous mid-terms, and we believe that many more possible applied problems can be introduced in each day's lesson. In addition, students are now writing about their mathematics. The discussion section of the MIP is not simply an answer that is double-underlined. It is the student's attempt at answering an applied problem and explaining the results to a "customer".

In closing, MIPs offer a technique to get students in the habit of solving applied problems in a real-world context. Finding possible MIPs are not hard. In fact, during graduation week 2002, all of the instructors in MA104 formed six teams, each concentrating on one MIP topic. For that week, each team developed a few possible MIPs. This gives instructors some ownership in the course. It also broadens the pool of possible problems, as most textbooks have very similar related rates or optimization problems, etc. Perhaps we'll see another *Far Side* cartoon making a comeback: the one where the devil is in a room where all of the books are entitled, "Word Problems."[2]

[2] A cartoon entitled, "Hell's Library". Copyright by Gary Larson.