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Inside This Issue

The Long Goodbye

While the title of this column is reminiscent of Ronald Reagan's farewell address to the nation after he was diagnosed with Alzheimer's disease, this column is not to announce the demise of *JPTEO* or its editor-in-chief. Rather, it is to announce a significant milestone in my life. On May 31st, 2008, I formally retired from Illinois State University (ISU) following 30 years of uninterrupted work. I now look forward to continuing part time work at ISU starting with the autumn semester. Having been a 12-month employee for the past three decades, I am now looking forward to the summer months as the beginning of a new chapter in my life. Note that I did not say "rest and relaxation."

I have been very busy during my professional life. I was always working on a wide variety of projects, not the least of which was the further development and improvement of the Physics Teacher Education program here at ISU. What little vacation time I have had, I almost always took it when I was involved in paid summer grant work providing professional development opportunities for in-service physics teachers. In retirement I expect to be fully engaged. When asked why I was retiring at 55 years of age and supposedly at the top of my game, I have often remarked, "I'm not retiring to do less, but to do more."

Now that I will be sharing work duties with my full time replacement, I will have more time to work on special projects. One will be *JPTEO.* I hope to spend more time encouraging authors and promoting the publication. I also plan to continue working in the areas of recruitment, preparation, and retention of high school physics teachers. I hope to share with others the work of the *Illinois Pipeline Project* for the recruitment of the next generation of high school science teachers. I plan to continue working with my daughter, herself an in-service high school physics teacher, on the writing of a textbook tentatively titled *Teaching High School Physics.* I also expect to continue offering workshops for professional development of high school physics teachers. Lastly, I want to continue working on the proposal for NIPTE - the National Institute for Physics Teacher Educators. These activities, interspersed with travel for leisure and to make conference talks should then make up the bulk of my retirement activities for the next decade or more. A long goodbye indeed!

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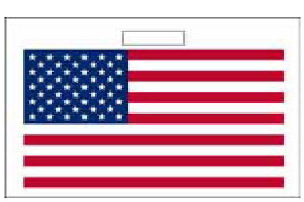

Hooking physics up with physical education

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High stakes testing and school accountability are "hot topics" in education today. School administrators, teachers, and students must do well in these areas in order to "prove" their teachers are "teaching," their students are "learning," and their schools are wisely using resources to prepare students to become good citizens and competent workers after completing their educational careers. Educators have been searching for a "magic pill" that could be administered to students that would enable students to obtain high test scores and thus, "prove" that schools are accountable and educating students to their highest potential possible. The authors postulate that high school physics may be that "magic pill" and may be one of the best kept secrets in American Education. In addition to reversing the traditional sequence of teaching science courses, the authors suggest another way to teach and learn physics is to "hook up" physics with physical education. This novel concept would be a collaborative effort between the physics teacher and the physical education teacher that would be a "match made in heaven!"

Our American educational system is "under a microscope of scrutiny." High stakes testing and accountability are two of the newest "slides" under investigation. Educators for many years have been searching for a "magic pill" that teachers can administer to their students that will enable them to obtain high scores on high stakes tests. These high student test scores, according to some experts, "prove" that a school is accountable; however, as far as we know, there is no "magic pill" available at the present time. We postulate that high school physics may be one of those "magic pills." Students taking physics learn how to solve problems and how to develop critical thinking skills that are essential to future success in any field of endeavor. We'd like to share a few of our reasons we believe high school physics may be one of the "magic pills" we've been searching for in education.

Why do we believe that physics is the answer?

"Physicists have generally maintained that the power of physics lies not only in a body of knowledge, useful as that is, but rather in a way of thinking" (Grayson, 2006). Some of the benefits of taking a physics course are as follows:

1. "In order to work physics problems and understand other content areas, students must be able to read and comprehend short paragraphs packed with information.

2. Physics develops both math and verbal skills; therefore, the ability to do well in these content areas will be enhanced by taking physics.

3. To understand the concepts of physics, students have to use analogies.

4. Physics courses teach students to think, a valuable skill apart from the knowledge of physics" (Rogers, 2007).

"The significant advantages of taking high school physics is one of the best kept secrets in American Education" (Rogers, 2007). Here are six of many reasons students should take a high school physics course:

1. "Modern technology comes from physics.

2. Physics is required in order to understand concepts in other sciences.

3. Physics classes help polish the skills needed to score well on the SAT and emphasize both math and verbal skills.

4. College success for virtually all science, computer, engineering, and premedical majors depends upon passing physics.

5. Physics classes hone thinking skills, a valuable skill apart from the knowledge content of physics.

6. The job market for people with skills in physics is strong. Engineers are applied physicists and comprise the second largest profession in America with about 1.4 million members" (Rogers, 2007).

Physics is a course that many students fail to take in high school because they believe: (1) it's boring; (2) it's too hard and a high level of mathematical skills is needed; and (3) it doesn't provide practical applications for their future lives. Can anything be done to reverse this thinking and can students be encouraged to take physics courses? Yes, we believe there are several concepts and ideas that have been implemented by reformers in the field of physics education that have merit. One idea is to teach physics to **all** students during their first year of high school as opposed to teaching a few advanced students during their last year in high school.

Changing the sequence of science course instruction:

Some reformers believe the traditional sequence of teaching science courses is not "etched in stone." Physics-first, in which physics is taught during the first year of high school, "provides a radically different paradigm to teaching science. The Physics-first movement inverts the traditional science sequence by teaching physics to ninth-grade students" (Dreon, 1997). "Marge Bardeen and Leon Lederman, one of the 1988 Nobel Prize recipients in Physics, are a part of a science education reform called Project ARISE" (Pattanayak, 2003.) In the ARISE program the order of biology, chemistry, and physics are reversed with physics being taught the first year, chemistry the next year, and biology the third year.

However, the concept of Physics-first has not replaced the traditional sequence of teaching physics in a large number of high schools across our nation. Recently, the San Diego Public School District, which was one of the largest school districts in the nation to implement a Physics-first program in their high schools, decided to drop the program after five years of teaching physics to their students during their first year of high school (Gao, 2006).

The Physics-first movement is in a state of flux and additional research is needed to determine the effectiveness of reversing the science sequence in the typical high school curriculum. Another idea we postulate is to "hook" the physics teacher up with the physical education teacher. These teachers would work together as a "team" and collaborate in teaching their students. This concept would work much like the special education resource teachers who collaborate with educators in regular classrooms to provide specialized help for students with disabilities.

Connecting to physics with physical education:

"The laws of physics, especially those pertaining to mechanics and motion, have parallel relationships with the principles that dictate the foundations of psychomotor movement" (Downing, 1997). Numerous research investigations have documented "the relationship between scientific principles and physical education and sport movement" (Rasch, 1989). "Stevens (1994) and Moore (1992) suggest using PE skills to reinforce concepts in such academic disciplines as physics, mathematics, history or art" (Downing, 1997).

"Since the fall of 1999, Timothy J. Gay a professor of physics at the University of Nebraska-Lincoln has been teaching physics to the largest physics class in the world – the fans that attend the University of Nebraska Cornhuskers' home football games in Memorial Stadium" (NSTA Express, 2006). Physics "lessons" are displayed on huge television screens. These lessons "cover such topics as Newton's laws of motion (blocking and tackling), projectile motion (kicking and punting), kinematics (open field running), and the ideal gas law (why not fill the football with helium to get a better hang time?" (NSTA Express, 2006). The Nebraska segments can be viewed on the Web at http://physics.unl.edu/outreach/football.html.

Gay's success at the University of Nebraska illustrates the potential of physical education teachers collaborating with physics teachers. The principles of physics are imbedded in physical education and athletic endeavors. There are several principles of physical education that can be used to illustrate the laws of physics. Among these principles are Newton's Laws of Motion and the use of levers in simple machines.

Newton's first law of motion:

"Newton's first law of motion states that 'An object at rest tends to stay at rest and an object in motion tends to stay in motion and in the same direction with the same speed and in the same direction unless acted upon by an unbalanced force'" (Henderson, 1998). Interior football linemen have a large body mass; therefore, when blocking a defensive lineman it is more difficult for an offensive lineman because of body mass and Newton's first law of motion.

Newton's second law of motion:

The second law of motion states that the "acceleration of an object is dependent upon two variables – the net force acting upon the object and the mass of the object" (Henderson, 1998). Basketball and soccer athletes are in constant motion and are in excellent physical shape. An obese participant would have more difficulty increasing his/her acceleration as compared to a slimmer athlete with less body weight and mass.

Newton's third law of motion:

Newton's third law simply states that "for every action there is an equal (in size) and opposite (in direction) reaction force" (Henderson, 1998). An example of this law occurs in baseball when a ball is thrown by the pitcher to the batter and the hitter swings a bat and makes contact with the ball. "The baseball forces the bat to the right (an action); the bat forces the ball to the left (the reaction)" (Henderson, 1998).

Levers and simple machines:

The muscles in the human body are not self-sufficient. Muscles are attached to the skeletal system and the nature and site of the connection determines the force, speed, and range of the movement produced. These three characteristics can be modified by the use of a lever that is attached to the particular muscle in question. In the human body, each bone is a lever and each joint is a fulcrum" (Martini, Ober, Garrison, Welch, & Hutchins, 2001).

There are three types of levers found in the human body: a first-class lever; a second-class lever; and a third class lever. A lever has three components – fulcrum (a fixed point), resistance (load), and effort (force). Bones in the human body serve as the lever bar and joints serve as fulcrums. The things to be moved by the lever are labeled the resistance or the load to be moved. The push or pull that moves the lever is called the effort or force required to move the lever.

In a first-class lever, the fulcrum is between the applied force and the resistance load. The closer the fulcrum is to the load, the easier it is for the applied force to move the load. An example of a first-class lever is an elbow extension that occurs when the triceps applies force to the olecranon (the effort or force) at the elbow (the fulcrum)" (Griffing, 2007). Please see figure 1 for a graphic representation of a first-class lever.

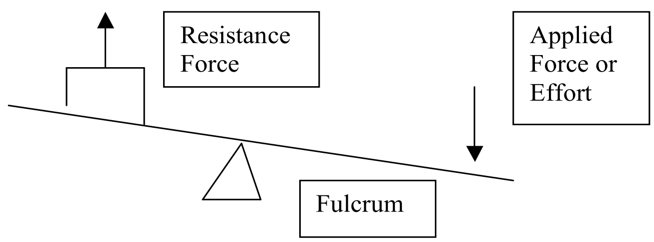

Figure 1. *A first-class lever.*

A second-class lever features the fulcrum on one side, the force on the other side, and the load in the middle. The weight of the load is the resistance and lifting the handles is the applied force or effort. Since the applied force is always a greater distance from the fulcrum (the fixed point) as compared to the resistance, a small force can be used to balance the load. That is, the effective force is increased. One example of a second-class lever is the plantar flexion of a foot to raise the body up on the toes. The ball of the foot serves as the fulcrum as the ankle flexors applies force to the calcaneus (the effort or exertion applied) to lift the resistance of the body at the tibial articulation (resistive force) with the foot" (Martini, et. al., 2001). Please see figure 2 for a graphic representation of a second-class lever.

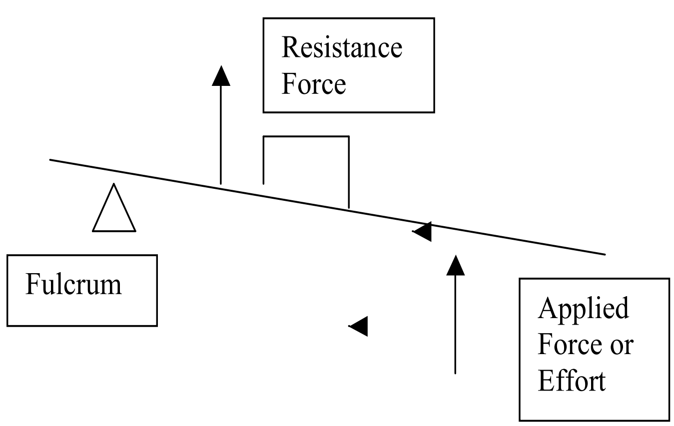

Figure 2. *A second-class lever*

Third-class levers are the most common levers in the human body and are vital to the success of athletes and physical education students. In this system, a force is applied between the resistance and the fulcrum. One example of this type of lever is an "elbow flexion that occurs when the biceps and the brachialis pull the ulna, the exertion (or effort) lifting the forearm, hand and any load (the resistance) at the elbow (the fulcrum)" (Griffing, 2007). Please see figure 3 for a graphic representation of a third-class lever.

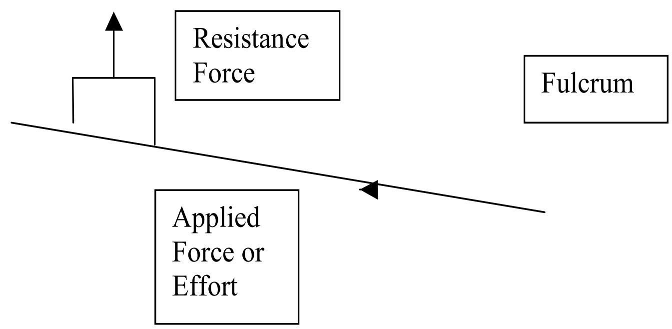

Figure 3. *A third-class lever.*

Conclusion:

Physics is a class that many high school students fail to take because they think it's dull, difficult, and has no practical application. The benefits far outweigh these misconceptions held by many students who wish to take the easy road during their high school years. High school physics has many practical applications and helps students develop both math and verbal skills. It teaches students to use higher order thinking skills to solve problems. Students must be able to read and comprehend information and use analogies to solve problems in physics.

We believe Physics-first courses at the high school freshman level and the collaboration of physical education teachers and physics teachers would enhance the interest of students in taking physics. A marriage among physical education teachers and physics teachers would truly be a "match made in heaven!"

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Guidelines and methods for high school teachers for encouraging women in careers in science, technology, engineering, and mathematics

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As the nation competes globally, it must take advantage of all capable and interested men and women to move forward. As most students begin to make careers choices in their secondary years, high school teachers must take the responsibility to encourage women into STEM professions. Discerning factors that often result in discouraging women in STEM careers are followed by fifteen guidelines for high school teachers to encourage women in STEM careers and prevent them from being lost in the pipeline. A number of teaching and learning methodologies are then introduced, that show how teachers on a daily basis can apply these. Suggested curricula for methodology implementation are also presented.

Ever since and even before the publication of *A Nation at Risk* (The National Commission on Excellence in Education, 1983), the United States has recognized the need for more scientists, technologists, engineers, and mathematicians in order to compete globally on intellectual and economic levels. The past 30 years of struggle to encourage students into STEM (science, technology, engineering, and math) careers has improved the situation slightly, but not to the extent needed by the nation, people are now attempting to determine the reasons behind this intellectual lapse. Specifically, researchers are targeting underrepresented groups in STEM careers, including females.

As it is the responsibility of every high school teacher to encourage students to pursue careers that are not only challenging and fulfilling, but also a service to the nation, teachers must be made aware of the problems encountered by many girls and young women who may be interested in pursuing a STEM career.

Females make up 45% of the U.S. workforce (Northwest Regional Education Laboratory, 2003), yet only 20% of engineers are female (True Outcomes, 2005). Furthermore, disparities exist within STEM careers – women tend to dominate fields of social science and biological science. Among graduate students in the year 2001, 74% of psychology and 56% of biology students were female, while only 27% of computer science and 22% of engineering students were female. Furthermore, the percentage of female computer science graduate students has dropped in the last two decades (National Science Foundation, 2007). Women tend to choose so-called "soft sciences" while men are more likely to pursue sciences such as physics and astronomy. Why such a drastic difference?

While there exist a myriad of different political entities that have passed legislation and enforced regulations to assist women in STEM institutions with the disadvantages they may have, including universities and workplaces, the "budding years" of the development of an interest in STEM careers is often overlooked. Institutional regulations to help women face common challenges treat only the symptom of a national "sickness," and do not treat the ailment itself.

DISCERNING FACTORS

Before treating a sickness, doctors should become aware of the cause of the ailment. Females tend to excel in math and science early in their education but, in every step up the educational ladder, from high school through doctoral education, fewer and fewer females choose to continue in STEM. Few young women ever enter into or continue in the STEM pipeline for a number of reasons, including the following:

Values

While many factors contribute to a student's choice of career, for females, the dominant factor for a female appears to be her value system. According to a study by Jecquelynne Eccles at the University of Michigan, for many girls, the most important characteristic of their choice of career is the ability to help and care for others as well as "how much they value working with and for people" (*Science Daily*, 2003). Many females want to have a direct impact on the lives of people, making careers in psychology and biological sciences so attractive.

Ability

While some studies show that although there may be differences in performance of math, science, and engineering skills between young men and women, there is no cognitive difference (Committee on Science, Engineering, and Public Policy, 2007). While the perception of ability does not appear to be more important to females than does their value system, females are often actively discouraged from STEM careers when either they perceive themselves as incompetent, or when they think that their teachers perceive them as being incompetent. In one study of university computer science students by Cohoon (2001), retention of females was more closely related to what they believed their professors thought about their career choice rather than how well suited they believed themselves to be for their major (Allison & Cossette, 2007).

Stereotypes

The popular perception is that those with careers in STEM are focused on *things*, and not on people. The concept of the "mad scientist" being a white, older male who wears a lab coat and neglects his wife and children is rampant. Perhaps more harmful, however, is the covert gender-stereotyping of science and engineering as involving male activities (Allison & Cossette, 2007). Personalities of scientists and engineers are also often stereotyped (Allison & Cossette, 2007), including being "nerdy" or "non-nurturing." Stereotypes lead to a conceptual image of a STEM lifestyle that is unattractive and undesirable to many girls.

Bias, Harassment, and Sexism

Although many regulations and active promotions of women in STEM are at work to ensure that women are not treated unfairly, bias, harassment, and sexism are still found. According to Boswell's 1985 study, the perceptions of a student's family, particularly by the father, can determine the attitude a female will have towards pursuing a degree in STEM (AWEP, 2005). Within the school setting, sexism can be encountered from other students, teachers, and counselors. The peer group might also help a student determine what classes are "cool" to take, and which are not. A common occurrence is for female students working in a male-dominated classroom to feel singled out or "stepped on." While females usually prefer cooperative learning, males may prefer competition (Allison & Cossette, 2007).

GUIDELINES AND PREVENTATIVE MEASURES

After analyzing the many factors that might contribute to a student steering away from the STEM pipeline or leaving it, 15 corrective and preventative measures can be taken by high school teachers of STEM disciplines.

1) Encourage Careers

While it may be assumed that many females will choose a non-STEM degree over a STEM degree, it is often overlooked that they may not be considering a degree at all (Allison & Cossette, 2007). The first step towards identifying student interest is to make them see that getting a degree *is* important and possible to attain. Teachers should remind students that earning a degree can not only widen one's understanding and appreciation about the world, but it also can result in a much greater income compared with those who do not have higher education. Education results in a far greater control over one's own life.

2) Identify Interests and Values

Students are not always aware of their interests and values. Teachers can help them to identify their strengths and weaknesses through metacognition and self-regulation. Essentially, metacognition is the process of determining what one knows and what one doesn't know. Once students are made more aware of themselves, they may realize that a career in STEM fits their interests. Teachers and counselors might work together to help students take interest and value inventories to determine what careers they might pursue. Furthermore, as many females do not directly coordinate career options with aptitude, students should never be "screened" for STEM based on aptitude alone. Promoting such practices may not only conflict with a student's desires, but give the impression that all engineers have to be proficient in all areas of STEM.

3) Familiarize Students with STEM

Often, students will major in a degree without understanding their other options. Worse, students who originally considered a STEM career begin to deviate from their original plan with every transition to higher education (Committee on Science, Engineering, and Public Policy, 2007). For example, a student who has an interest in anatomy might consider becoming a vet without even being aware of biochemical engineering – perhaps a more attractive career. For many, the concept of engineering is abstract and intangible. Many children think of an engineer as a person who runs trains. Class activities that involve career exploration on a more advanced level should be employed throughout the year. Guest speakers from STEM professions should be invited to share their career experiences to allow students to truly see what STEM professionals do on a daily basis.

4) Build Confidence

Students are often intimidated by STEM subjects in school because of the perceived difficulty. Teachers must provide consistent positive feedback to students to let them know that they *can* do the work and be successful at it. Unfortunately, according to studies by Britner and Pajares (2006), greater success of females in the classroom does not directly correlate with increased self-confidence. Often this requires a re-focusing on the dominating characteristics of success as being *internal*, not *external* to the student. Students must be held responsible for their own learning, and should feel empowered as a result.

5) Display Practical Utility

Students often demand to know what the subject matter has to do with their own lives or what it will be useful for. According to Eccles, females often desire a career that fulfills a need to know specifically how skills in the classroom will be used in their future career (*Science Daily*, 2003). The importance of what is taught in the classroom should be explicitly expressed on a regular basis by teachers. Case-studies, problem-based learning activities, and high-interest topics relate classroom material to their lives. Projects can be undertaken that fill a current need in the community or that make life easier, resulting in students seeing that even their current education is applicable to their desire for making a difference in the world by helping people directly.

6) Provide Role Models

Providing female and minority role models alone is not effective for encouraging women in STEM careers (Phillips, Barrow & Chandresakhar, 2002); however, it can assist in reducing stereotypes that many might have about STEM professionals. Providing role models can be as simple as studying a biography or inviting a STEM professional into the classroom for a day. What is of greatest importance is that seeing a role model should break the mold of what is expected by students. For example, it might not be most effective to study the biography of Isaac Newton as scientists are often viewed as being male, white, bad-humored, and single. A more effective role model might be a minority in her field, such as astronaut Ellen Ochoa who can give clear testimony to her successes despite the perceived limitations placed on women and minorities in science.

7) Engage Students with Hands-On Activities

If students are to be encouraged in STEM careers, one of the best things educators can do for students is to provide them with experiential learning opportunities similar to those in which STEM professionals are engaged regularly (ITEST Learning Resource Center, 2005). STEM professionals engage in hands-on activities, and students should do likewise. One of the current dominating trends in math, science, and technology is the implementation of inquiry – the methods and processes by which researchers learn about the world. Furthermore, kinesthetic learning can be more effective for many students who fail at the traditional auditory-written methods used by many teachers. The *National Science Education Standards,* as well as many state standards for math, science, and technology, attempt to set the bar high for teaching and learning practices in the classroom, and teachers should do their best to apply the standards. Theory must evolve into practice in the math and science classroom, and this can only happen with engaging hands-on activities.

8) Build a Positive Environment

As a teacher's attitude toward student success can be more important than a student's attitude toward themselves when considering a career in STEM, teachers must emanate a positive attitude about success and future possibilities for each student. Teachers should strive to make the classroom a place where students want to learn. Positive reinforcement should be used in preference to negative punishments, and students should be encouraged to lift each other up in a collaborative atmosphere rather than put each other down in a competitive one. Successes should be celebrated as a class, and dignity should be given to each student and their work. When students see that their work has value and is praised, students will continue to want to pursue STEM-related learning.

9) Utilize Cooperative Learning

Cooperative learning should included among the most effective practices in science education as noted in *How People Learn* (National Academy of Sciences, 1999). Cooperative learning is different from "group work," in that students learn together in an integrated, interdependent way. Students are often given roles, but the project is effectively done in a collaborative way (students do not work independently and then group afterwards). Cooperative work is not only a vital skill for all life and for STEM careers, but helps students to learn classroom skills and content better – essentially helping students to build the confidence needed to pursue STEM careers. Teachers can utilize cooperative learning best by centering instructional practice around core projects in which students are challenged to become interdependent upon one another.

10) Communicate with Family

Among the keys to student success in education, parent-teacher communication is one of them. Because the stereotypes about STEM careers are so rampant even among adults who are currently in the workforce, teachers must also educate parents of students. According to a 2005 assessment by the Assessing Women in Engineering project, more educated parents tend to encourage their daughters more into STEM careers, and mothers predominantly help their daughters make enrollment choices for college (AWEP, 2005); therefore, parents must be both educated and encouraged about the options and benefits of STEM careers. Teachers can promote communication with students' families by e-mails and phone calls. Other ideas for communication could include class newsletters, science fairs to showcase student work, as well as passing out brochures about STEM careers to families during school open houses.

11) Defeat Stereotypes

Stereotypes about STEM professionals exist in students' homes as well as in the classroom. In particular, an effective recruitment strategy is to portray STEM careers as being welcoming and accommodating to females (ITEST Learning Resource Center, 2005). Although sexism and bias can occur, female students should be ensured that many supportive programs and organizations are available to help overcome any obstacles that might be encountered – women can still be feminine even when working it what may be portrayed as a man's world. Laws guaranteeing women equal opportunity and protection from harassment should also be brought to the attention of the student as well.

While defeating stereotypes at home might require extraordinary teacher-parent contact, defeating them in the classroom is possible. Teachers should choose textbooks and supplementary materials that portray people of both genders and all diversities engaging in STEM-related activities. Posters can create an especially good climate by reinforcing the concepts that STEM professionals are all different and unique. Furthermore, teachers should be explicit about eliciting, identifying, and confronting stereotypes just as another form of misconception that students hold. Teachers would do well to help students recognize that they might covertly hold ideas (not always necessarily bad) about STEM professionals that simply are not true.

12) Teach 21st Century Skills

Students need to learn modern skills. Two of the most important skills identified in successful recruitment programs include critical thinking and group collaboration (ITEST Learning Resource Center, 2005). While learning how to do long division is an important basic skill, students often find greater value in skills that they envision themselves employing on a daily basis. For example, many students find great interest in computer programming and building objects. As STEM careers rely on ingenuity and invention, students should experience the joy of their own abilities to design and create. Modern lab skills and data analysis are also of great value. Technology is key to teaching 21st century skills.

13) Foster Persistence

Even when students are initially attracted to a particular subject, some concept or another will become difficult, and many students will find it easy to give up on themselves. Fostering persistence is a key element in developing a lasting self-confidence that females need throughout the STEM pipeline. Parents should become part of the process, as encouragement at home is integral to giving long-term support. Students must be given both challenging and long-term projects to allow them to practice and develop the virtue of persistence. Teachers should celebrate student achievements.

14) Set High Expectations

Teachers seem to unanimously agree that the Pygmalion effect is very applicable in education. Teachers who enunciate high expectations for their students tend to see much better results from their students. Students should feel appropriately challenged by course content. Teachers can ensure that their courses are challenging by aligning what they teach with national and state standards for math, science, and technology.

15) Encourage Mentoring

Numerous studies have shown that the single most effective method for encouraging women in STEM careers is mentoring. Some would even claim that it is a "proven practice" in effective recruitment (Allison & Cossette, 2007). Many mentoring programs are available through schools and professional organizations. However, if a school does not have a program, teachers should be encouraged to begin a program – one that might easily begin with retirees from the community as mentors. Universities and professional associations should also be contacted, including local chapters of the Society for Women Engineers of the Association for Women in Science. Professionals in Rotary International, Lions, etc., are also good places to start a search for individuals who might be willing to mentor a student. Formal or informal, mentoring is the one opportunity that students have to develop a personal and professional relationship with someone who has many skills and values to teach. Mentoring allows students to not only have a personal role model in their lives, but provides hands-on experience, pre-professional training, and can get students a "foot in the door" for whatever career they choose.

Each of the 15 suggestions listed above might seem overwhelming to employ on a daily basis, but they are none other than the foundation of good teaching. Hopefully, many of these practices are already employed regularly in the classroom. Still, it is important to keep them in mind, as they not only are good teaching practices, but are doubly important in encouraging young women – and men – to pursue STEM careers. Furthermore, all teachers and administrators can attack the pipeline problem from many levels, including in the classroom at the small group and individual level, as well as through special programs and extra-curricular opportunities.

For a more all-encompassing understanding of how to promote young women in STEM careers, a study of various methodologies, curricula, and standards is helpful in piecing together the 15 practices.

METHODS AND PEDAGOGICAL PRACTICES

Metacognition and Self-Regulation

Metacognition refers to *knowing what one knows and what one doesn't know*. Often, students lose confidence in a particular subject because they find it confusing – in most cases, students understand many parts but may have a difficult time with one or two aspects. For example, when solving a complicated math problem, students may refuse to solve a problem because they "don't get it." When asked what part about it they "don't get," students struggle to give an answer. Students often do not take the effort to scrutinize their own strengths and weaknesses, and therefore develop a biased view of their own capabilities.

Self-regulation refers to the active process of identifying one's strengths and weaknesses and addressing them accordingly. Teachers must model this practice. When giving homework problems, teachers might ask students to complete problems, and if they don't know how to get the answer, to explain what piece of information they believe is missing or to specifically state the process for which they are confused. Providing students with practice homework and formative assessments (not always for a grade) can also be helpful, as poor performance on such tasks can indicate key areas in which students are having problems. Diagnostic tools can be especially helpful to teachers. Many tests in math and physical science are available to teachers from Arizona State University, including the Force Concept Inventory, Mechanics Baseline Test, Test of Understanding Graphs in Kinematics, and Math Concept Inventory (Modeling Instruction Program, 2007). Tests can be given as pre-exams at the beginning of the year and again as summative assessments to see specifically which misconceptions still need to be treated. Concept tests are questions that help students identify misconceptions by providing situations that provide an opportunity to highly critical thinking. A very effective web site, Diagnoser Tools, helps students to identify their own understandings and misconceptions, known as "facets," by providing concept tests (Diagnoser Tools, 2004). If a student answers a question incorrectly, a follow-up question is given that asks the student to explain their reasoning. If the reasoning appears to fall into a typical error category, the web site explains to the student their faulty logic and asks them to try the same question again. An analysis tool is provided to teachers to identify the specific misconceptions that students have.

Cooperative Learning

As mentioned previously, cooperative learning is the use of group partnerships to enhance learning. Different from "group work" in which students work independently and only later compile their personal efforts, cooperative learning entails students working within different roles to help solve problems in a team-based atmosphere. Each team member is held accountable for himself or herself, and is held accountable for each other team member as well. Teachers can promote cooperative learning by carefully designing in-class, monitored learning opportunities that require full engagement of every student at all points during the investigation, while holding team members accountable for each other through self and peer assessments. Inquiry, problem-based learning, and case-study styles of teaching and learning are very conducive to cooperative learning.

Problem-Based Learning

Problem-Based Learning (PBL) is a teaching method that uses a real-world problem that must be solved by students within the context of not only content and skills learned in the classroom, but with considerations for ethical, moral, and value principles. For example, students studying the nation's "energy crisis" in physics might be placed in charge of making arguments for determining the best form of energy production – students might study the social and moral implications of the use of nuclear energy, for example. PBL activities not only fulfill female students' preference for cooperative learning, but also provide real-world context that relates classroom curriculum to the current needs of human beings.

Case Studies

Case studies are similar to PBL's in that they involve current, real-world problems. The difference, however, is that case studies have already been "solved" or at least dealt with, and students are generally asked to be more analyzers of current solutions as opposed to solving problems on their own. Case studies can last as little as a class discussion, or can last throughout an entire unit. Case studies fill the need for real-world applications and can help students to become familiar with how STEM is currently applied. An excellent resource for case studies comes from the University at Buffalo web site from The State University of New York (National Center for Case Study Teaching in Science, 2007).

CURRICULA

Project Lead the Way

Project Lead the Way (PLTW) is a nationally recognized curriculum that has been developed to fill the gap in STEM careers for women and minorities and to increase enrollment of STEM-related degrees and programs to fulfill a national need (Project Lead the Way, 2006). The curriculum melds math, science, technology, and engineering into a set of three core courses and a myriad of extended courses that may include biomedical engineering and aerospace engineering. Within the courses, students take part in activities and significant projects that familiarize students with modern technology and skills while learning essential math and science concepts.

Modeling Method of Instruction

The Modeling Method is an approach for teaching science that has come out of a large amount of conceptual-based learning research through Arizona State University (Modeling Instruction Program, 2007). While the current focus of the Modeling Method is on the physical sciences, many applications can be brought into mathematics courses. The Modeling Method employs the use of computers and modern technology to derive graphical and mathematical models relating two or more variables in any system. A large portion of the Modeling Method relates to the use of whiteboarding, an event in which students present their findings in small groups in front of the classroom to encourage class consensus. The method discourages the emphasis of textbooks, and instead helps students to become principal investigators instead of just observers or verifiers. Students take an active role as researchers in the laboratory, and build knowledge and understanding in groups, increasing their confidence and group skills. Students not only become more comfortable with using critical thinking and data analysis skills through the Modeling Method than through other traditional methods, but develop a sense of the power within themselves to learn about the world.

Extracurricular Programs

Many special programs and extra-curricular activities through school can also be effective at promoting girls in STEM careers. For example, after-school programs such as JETS, FIRST, Team America Rocketry Challenge, scouting, and 4-H could be actively promoted by STEM teachers. School-wide support of such programs can eventually lead to foster a positive, supportive atmosphere for young women. Tutoring and mentoring centers may have the greatest effect of all. In tutoring centers, young women who are struggling in STEM courses can get extra support from faculty or even peers. Peer tutoring programs also offer students the opportunity to be tutors themselves – thereby giving students the opportunity to boost their own confidence and directly help others with their STEM understandings. Mentoring programs would be an excellent addition to a school's activities.

IN SUMMARY

As the nation continues to strive for success and high academic standards for its students, high school teachers should attempt to help students develop their skills and interests to carry them along the STEM pipeline into college and eventually into a career. Teachers should view the fifteen guidelines not only as goals to achieve in the classroom, but as evaluative tools for what is currently taking place between teachers and students. By following the fifteen guidelines, teachers will be more likely to have an impact on encouraging women into STEM careers while increasing their own development as professional educators. Teachers of science, technology, engineering, and mathematics would do well to consider reviewing the many methodologies and curricula presented here, along with the myriad of professional development opportunities that accompany them. With the combined effort of high school teachers across the nation can we expect to begin to close the gap between men and women in STEM careers to prepare a nation that must compete globally.

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A post participation review of the North Carolina State University's online graduate credit physics course for teachers PY610C: Special Topics – Matter & Interactions II for Secondary School Teachers

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A high school physics teacher reviews PY610C – Special Topics: Matter & Interactions II for Secondary School Teachers, an online graduate credit course offered by the North Carolina State University. Some aspects of this course that enhanced my learning experience included the videotaped classes, the hands-on lab experiments, and the online teleconferences. While the teleconferences were helpful, one of the negative aspects was that participation was not mandatory and therefore many students did not attend them. Another difficult aspect of the course were those lab assignments using the VPython computer modeling software -- while the programs were useful visual aids, creating the computer programs was difficult. Overall, the course was enjoyable and a worthwhile learning experience for teachers who want to improve their knowledge of electricity and magnetism. There are some minor credit transfer caveats. *

Introduction:

The North Carolina State University (NCSU) Physics Department offers several on-line graduate credit courses for teachers who want to improve their conceptual understanding of physics as part of professional development. Here I present a post participation review of PY610C - Special Topics: Matter & Interactions II for Secondary School Teachers, which I took in Fall 2006 for credit toward my M.S.Ed. (Physics) degree from Buffalo State College (Buffalo State College, 2008). I found PY610C to be a worthwhile investment. PY610C improved my conceptual understanding of electricity and magnetism, made it easier to understand the abstract concepts in E&M, and helped me see how the fundamental principles of physics apply to the array of problems one encounters in E&M.

Literature:

In recent years, online courses have gained in popularity. However, there are still many questions about them. In a letter to the editor of *The Physics Teacher*, James O'Connell (2001) asked several questions about the logistics of teaching an online course, including how to handle student questions, how to have students perform laboratory activities, and whether students learn as much in this medium. These are some issues that professors need to consider when deciding whether to teach a physics course online and how to design the course if they do decide to teach it.

The online environment is very different than the traditional classroom, and physics teachers need to modify their current classes in order to meet the needs of students in this environment. The traditional method of lecturing does not lend itself to the online format as well as it does to the regular classroom (Abdelraheem, 2003). In the online environment, students have a great deal of responsibility for their learning, Therefore, course expectations need to be clearly defined so that students know the amount of work they need to complete on a daily/weekly basis (Radnofsky & Bobrowsky, 2005). Teachers also need to facilitate discussion among students in an online class and "promote active learning" (Boada, 2001).

There are many advantages to taking a physics course online. Online courses allow access to a greater number of people. Many students who take online courses work, have families, or live far away from the college where the course is being offered (Radnofsky & Bobrowsky, 2005). In addition, online courses might increase a student's level of participation. In a normal classroom, students learn how to avoid participation. However, many online courses include participation as a portion of the grade and therefore can encourage greater participation than traditional classes. In Chester & Gwynne's (1998) study, two thirds of students indicated that they were more likely to participate in an online class than in a traditional class. Anonymity may allow some students who do not ordinarily feel comfortable sharing their ideas in front of others to feel more comfortable with doing so. Howard Rheingold (1994 as cited in Chester & Gwynne, 1998) commented that people find "virtual communities treat them as they always wanted to be treated – as thinkers and transmitters of ideas and feeling beings."

Another advantage (particularly to working teachers) of online physics courses is that there is a great deal of schedule flexibility to the student. Physics students can do the coursework when it is convenient, at any time of the day or night, instead of being confined to the classroom for three hours every week (Smith & Taylor, 1995). Online courses also allow students to ask questions at any time instead of having to wait until they are in the class or for the professor's office hours (Merrill, 2001). The use of discussion boards is also an advantage that online courses have over traditional classroom course. Discussion boards offer a place where students can reflect on their learning. This allows

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teachers to keep a running tab on how students are achieving their learning goals for the course (web logs and online discussions as tools to promote reflective practice).

Even though there are many advantages to online courses, there are also several disadvantages. In this environment, students have a great deal of ownership over their own learning. Students need to be self-motivated and self-disciplined while taking an online course. Radnofsky and Bobrowsky (2005) found that several of the students that took their online course commented that it was more difficult to meet the high standards of an online course than a traditional course. There are many reasons why online courses can be difficult for students who are not self-disciplined. If deadlines are not strictly enforced, it is easy to let work pile up and become insurmountable (ibid; Pearson 2006). Also, in this environment, there is minimal interaction with classmates. When solving problems or working on a lab activity, there are minimal opportunities to see how others solve problems (Merrill, 2001). One final disadvantage of online courses is that one must not only have regular access to a computer but must also be good with computers (ibid; Pearson 2006). While taking an online course, many different types of technical issues can arise, either with accessing materials online, viewing a course lecture, or completing or submitting homework.

My Experiences:

During the summer of 2006, I was working towards my M.S.Ed. (Physics) degree from SUNY-Buffalo State College (Buffalo State College, 2008; MacIsaac, Henry, Zawicki, Beery & Falconer, 2004). Because I live in Southern New York State, about six hours by car from Buffalo, I had to look at online course options for the fall semester in order to complete my degree. I had recently taken an intensive three-week summer academy course in electricity and magnetism at Buffalo State called PHY622 that included some brief readings from the first edition of the *Matter and Interactions II* text (Chabay & Sherwood, 2007). Because I have always struggled with electricity and magnetism, I felt taking another course on this topic would be a good idea. I had several different courses to choose from; I decided to take *Matter and Interactions II* for Secondary School Teachers. I had heard many good things about the course and about the instructor from Buffalo State faculty and colleagues, and I felt it would be a worthwhile endeavor.

The North Carolina State University Department of Physics course PY 610C: Special Topics: Matter & Interactions II for Secondary School Teachers is described in the department online literature as:

> *"This calculus-based course provides a deeper and broader understanding of the fundamental physics underlying the electricity and magnetism taught in regular and AP high school physics courses. Atomic nature of matter; emphasis on fundamental principles; computational physics (no prior) programming experience required; modeling messy real-world problems. Participants engage in reflections on the pedagogical consequences of the modern view of the subject. The course will assist teachers in helping their students understand current scientific research and discoveries." (NCSUa-c, 2006).*
>
> *Course prerequisites are a teaching certificate in science or mathematics, or permission of the instructor. Information on how to register for the course can be found on the distance learning website (NCSUa-c, 2006).*

In order to take the course, I needed to fill out an online lifelong education application. After this was completed, I was able to register for the course. The total cost for the three credit PHY 610C course as an out of state student in Fall 2006 was $1239 (in state students pay approximately $600 less). After signing up for the course, I had to sign up for WebAssign (an online homework system) (WebAssign, 2006), which was an additional $10. As a participant in the course, I was given access to the weekly teleconference sessions and access to the discussion forum. The textbook for the course, *Matter and Interactions II: Electric and Magnetic Interactions* (Chabay and Shwerwood, 2006a) cost approximately $85. There is also an optional experiment kit available for $45 (NCSU 2006c). The kit makes it possible to do several of the labs required for the class. It is possible to assemble the kit contents yourself; however, some of them are difficult to obtain. In order to complete the computer modeling labs, I also had to download and install the free VPython computer programming software (VPython, 2006). After registering for the course, I received a set of 4 CDs with interactive video lectures by Prof. Chabay, though Prof. Sherwood was the actual instructor of record.

In order to succeed in the course, a modern computer with internet access, an e-mail account, *Adobe Acrobat Reader* (freely available), and *RealPlayer* (freely available) was required in order to view the lectures. In order to participate in the online teleconference, DSL or a cable modem is necessary. Also, working speakers are necessary, and a microphone is suggested. Other information necessary for success in the course were available on the course website and individually from the instructor. The interactive video lectures were sent out immediately after registration for the course.

The course included weekly readings, labs, interactive lectures, homework assignments, three exams and a final. The exams were all short answer, including material from all aspects of the course. We were also required to make a weekly post in the discussion forum, and there was an optional Sunday night teleconference.

There was approximately ten hours of work required for the class each week. There were three classes per week, which were each approximately one hour. The lectures were unique since there are approximately three to five breaks during the lecture during which you are prompted to answer a question (either multiple choice or short answer). After you answer, the instructor displays a histogram of the original class responses, and a discussion of the correct answer ensues. These breaks provide you with an opportunity to check your understanding and reflect on the material in the lesson.

In addition to watching the lessons each week, there was weekly textbook reading, a lab activity and an assignment on *WebAssign*. The assignments on *WebAssign* reviewed the content of the lesson and the textbook reading. The homework assignments were often thought provoking. If homework assignments were done incorrectly, students had the opportunity to resubmit them up to four times for full credit. There was also a weekly lab that needed to be completed. The lab activities consisted of either experiments or computer modeling. The experiments involved investigating phenomena that were being studied in class. The computer modeling involved writing short computer programs in the *VPython* programming language that represented the phenomenon studied in 3-D in the class lecture. Prior knowledge of *VPython* was not required. The first computer modeling lab was an introduction to programming in *VPython*, and the subsequent labs included the programming knowledge necessary to complete the program.

Along with the above activities, students were required to make a weekly post on the discussion board. The post could either be a question or reflection on the recent work (which could include how it might potentially affect your teaching). You could either start your own thread on the discussion board or add to a thread that was already started.

Finally, there was a weekly teleconference every Sunday night. Here students were able to ask questions and clear up any misconceptions from the week. The instructor would take part of the time to ask an extension question and have us work together in small groups on the problem.

Findings:

Overall, I had a great experience in this course. My experiences as both a student and teacher of physics have taught me that many physics students lack a good conceptual understanding of electricity and magnetism. The course was focused on presenting a strong conceptual understanding of the fundamental concepts underlying electricity and magnetism and helped improve my understanding. The text authors and instructors are well-known scholars in Physics Education Research (PER) and curriculum development and are amongst the leading figures in the field for introductory electricity and magnetism teaching in particular (Chabay & Sherwood, 2007c).

Although it is an online course, the instructor made many different learning experiences available that went beyond many of the experiences in other online courses. The videotaped classes were a major strength of the course. They reinforced the readings and gave the experience of being in the classroom. I felt the breaks in the lectures gave the opportunity for a great deal of feedback during each lesson. I always had an opportunity to answer the questions presented to the class, and I was provided with feedback on both the correct and incorrect answers.

The online teleconferences were another advantage of the course. There was a great deal of interaction in these sessions. Students could either use the microphone or the keyboard to ask or respond to questions. All of the participants also had access to a virtual whiteboard. Many times the instructor would ask an application question, then break us up into small groups where we could discuss it on our own, then report back to the whole group. During the course of the week, I would often have questions about the topic we were studying and the online teleconferences provided me with an opportunity to get these questions answered. Although the instructor preferred questions relating the prior week's content, he was also willing to answer any questions students had. The teleconferences were like having built in office hours every week! Along with the teleconferences, students also had the opportunity to ask questions on the discussion board. Questions were often responded to by both other students and the instructor. Responses were often posted within a day, and the answers were often thorough. The instructor was also available via e-mail for any course related questions.

When studying electricity and magnetism, it is important to have concrete experiences in order to reinforce the learning from class. An advantage of this course is that it has hands-on lab experiments. The labs were not only measurement based. Students were asked to make predictions, give the reasoning for the prediction, perform the experiment, then go back to the original prediction and explain whether the results confirm or contradict your original thinking. The labs involved a balanced amount of thinking, experimentation, and reflection on the experiment. They helped build a conceptual understanding of the course material.

Another strength of this course was that technical issues were resolved immediately. At the beginning of the course, there was an issue with a defective course CD. Since the interactive video lectures were an integral part of the course, this was a significant problem. This issue was resolved immediately by the instructor; new CDs were shipped out to all of the course participants on the day that the problem was discovered.

One of the disadvantages of the course was the lack of participation in the teleconferences by many students. At the beginning of the course, the instructor asked for feedback on the scheduled day and time of the online teleconference. There was little negative response about the day and time, so the teleconferences were kept on Sunday night at 8:00 pm EST. In the beginning, most of the class attended the teleconferences. However, attendance was not a mandatory part of the course and as the semester went on, fewer and fewer people attended the sessions. By the end of the course, only approximately four to five students would attend the sessions. I think that it would have been beneficial to all students for the teleconferences to be mandatory because having greater participation would have enhanced the effectiveness of this part of the course.

The final product of the *VPython* labs (3-D visualizations of the concepts), such as the electric field of a single charged particle, electric field of a dipole, and path of a proton in a magnetic field were useful 3-D animations, which are very helpful visual aides. However, this is one aspect of the course with which I struggled. During the course of the semester, we completed twelve labs. Five of the labs were computer modeling using the *VPython* software. These labs would generally take one to three hours. We were given detailed instructions on how to complete the labs. However, even with these instructions, I still struggled with several of the labs. These lab activities required both an understanding of vectors and knowledge of the *VPython* software. Because this programming software was new to me, I experienced difficulty when I was trying to translate the physics into a working *VPython* program. This is one aspect of the course that I found too difficult to complete via distance learning (even with the opportunity to send it to the instructor for assistance). Although the final products were useful, I felt the experimental labs were a much more worthwhile learning experience.

I found the lab experiments to be extremely worthwhile. However, I found that I was often in need of a second pair of hands in order to do the experiments well. There were also two labs that I had to modify, because I had errors with my initial calculations. Being on one's own to complete the labs properly seems to be an unavoidable consequence of a distance education course with a lab component.

In order to succeed in the course, participants should have prior experience with the concepts of electricity and magnetism. If possible, it makes sense to take the Matter and Interactions mechanics course first, as it provides a strong foundation in 3D vectors, *VPython* computation, electric forces, and electric potential energy. The electricity and magnetism course has built-in review, which allows students to succeed without first taking the mechanics course, but less effort would be required for students who have taken the prior M&I course.

It is also important to have a working knowledge of calculus, including familiarity with derivatives and 3-D vector analysis because it is used throughout the course. The first day of class and homework assignment is a review of vector analysis of vectors in 3-D. Familiarity with computers is also important. Although no prior computer programming is necessary, it can be difficult to independently write computer programs. Some of the computer programs were difficult. However, it was nice to see a 3-D model when the computer program was complete.

I did encounter an issue when transferring credit to my M.S.Ed. (Physics) program at SUNY- Buffalo State. The NCSU PY610C designation is for an experimental course, granting grades of either satisfactory or unsatisfactory (S/U). I had to petition the transfer of such a course to my degree program, due to a standard policy that S/U courses not be transferred. At Buffalo State, only grades of B and above are routinely transferred. Luckily, Dr. Sherwood provided a memo explaining the experimental nature of the course and provided me with a letter grade. NCSU Physics is moving PY610C to a standard course designation with real letter grades, so you may not have to make such a petition.

Summary:

I feel my experience in this class was comparable to a traditional university course. The online nature of the course is its major advantage – it can be taken from anywhere in the country. There were several weeks where I put more than 10 hours into the course. This can create difficulty for working professionals. Trying to balance homework, labs, readings, and video lectures can be difficult while teaching a full load. In order to get the most out of the course, some time should be dedicated a few days a week in order to complete the weekly assignments. I felt the benefits I received from the course were well worth the time I put into it. The technology associated with the course can be challenging for those not comfortable with significant use of computer video playing, conferencing, or *VPython* programming. I STRONGLY RECOMMEND this course to any physics teachers that want to enhance their conceptual understanding of electricity and magnetism by learning the fundamental principles that govern electrical and magnetic interactions.

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