Teaching Mechanics 101

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Abstract

A typical class might start with a video and/or hands-on demonstration, lead to an example problem with theory provided just in time to allow solving of the problem at hand, and end with group work on another in-class example problem. Carefully worded questions draw the student into the learning and allow the student to draw upon previous knowledge to provide the building blocks for construction of new knowledge. Repetition and manipulation of new concepts is possible through the proper use of instructional technology. Sound innovative? Sounds new? Not really, these types of techniques have been used for many years at the United States Military Academy and probably at most schools at the turn of the century. Hands-on models were once the corner stone of every class in mechanics, but many classrooms today are only equipped with a textbook, a chalkboard (if lucky), and a computer projection system. Is this enough? No! How can faculty return to a style in today's classrooms that is more conducive to student-centered learning? This paper will present the daily classroom activities in a basic Mechanics course (and other courses as well) that greatly improve the quality of the instruction and student learning. Assessment will be provided to demonstrate the effectiveness of these pedagogical basics on the student learning and professor's classroom performance.

I. Introduction

So how do you like to learn a new concept? Read a textbook and/or journal article on the subject? Maybe throw in some type of experiment with technology to simulate the theory? Felder points out that in most areas we as faculty learn differently than how students learn best.[1] Our mission is to assist students with varying learning styles to learn new concepts. So how do students like to learn? How do they learn best? Considering the 1990 Seymour and Hewitt[2] study that shows 40 percent of engineering undergrads switch from science, mathematics, and engineering disciplines due primarily to poor teaching, maybe a discussion of engaging classroom activities that help students learn is appropriate.

What were the techniques used by some of the best teachers from the past? Maybe the authors cannot speak for all, but when they are students, whether attending a class or a workshop for improvement, they learn best by doing! Students expect the teacher to be motivated and passionate about the subject and help them understand the key concepts through an active engaging classroom environment. The environment could include video clips about the subject, models and demonstrations that the student can work with to better understand a concept (Figure 1), and experiments testing concepts and materials. They want to be pulled into the class through questioning and in-class activities. Bottom line, students want to practice in class what they will be doing on homework, exams and in real life. As shown in Figure 1 at the turn of the century at

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the United States Military Academy (USMA), the use of instructional technology such as the chalkboard and working with physical models was part of every class – how about today?

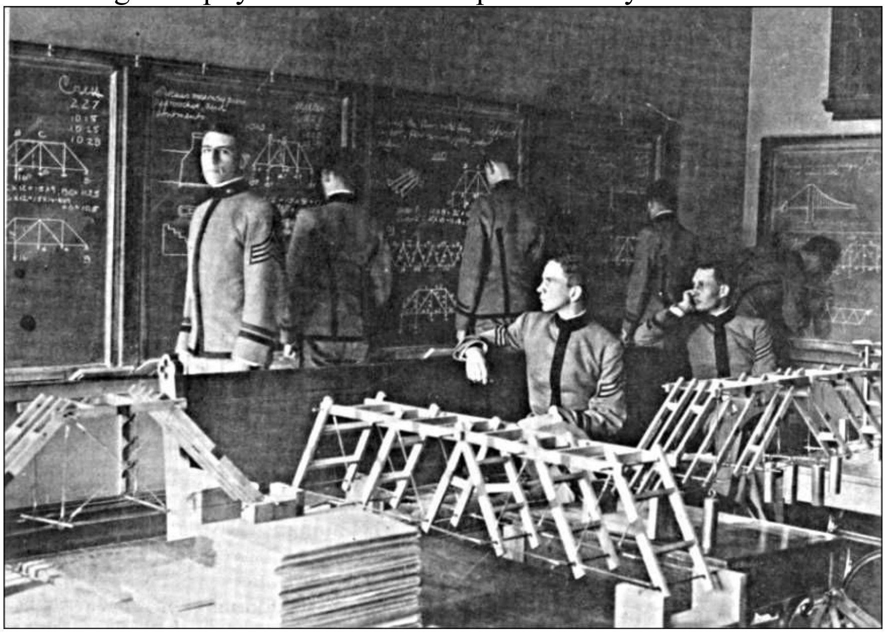

Figure 1. Truss Analysis at USMA at the Turn of the Century – Note Loading on the Models

All of these concepts and techniques are presented, demonstrated, and discussed during the ExCEEd (Excellence in Civil Engineering Education) Teaching Workshop (ETW). ETW is the direct descendent of the T^4E workshop, Teaching Teachers To Teach Engineering[3]. T^4E was funded through the National Science Foundation (NSF) for three years and was provided at USMA for engineering professors with less than four years of teaching experience, i.e., civil, mechanical, aerospace, electrical, chemical, etc. T^4E was such a huge success that ASCE decided to continue the program under the ExCEEd Teaching Workshop moniker with one caveat: the program was offered only to civil engineering professors with less than four years of teaching experience. The most critical and transformational part of ETW is the opportunity to learn new techniques, and then try them in the three practice classes presented by each participant.[4] Team members assume the role of students during the class and assessors at its conclusion. The senior mentor is the primary assessor for the first class, while follow-on classes are critiqued by all with the actual participant instructor leading the last critique with a self-assessment – essential for any improvement and/or maintenance of excellent teaching techniques. Self-assessments are the most subjective, but also extremely important, of the three types of assessment discussed and experienced.[5]

To date, there have been thirteen offerings of ETW: 1999- 2004 at USMA, 2000-2004 at the University of Arkansas and 2002 and 2003 at Northern Arizona University with each session having 24 participants. There were nine observers from the ASCE Program Design Workshop[6] at USMA in 1999 and six observers (two each from ASME, IEEE, and AIChE) at USMA in 2000. Today some of the participants have over 20 years of experience and are soon to be department chairs. In 2004, the workshop included mechanical, electrical, and chemical engineers under the ExcEEd (Excellence in Engineering Education) moniker.

Modifications to the original one-week T^4E program have been relatively minor. Most changes have dealt with the addition or deletion of a few supplemental topics. ETW, and previously T^4E, uses the six-week instructor-training model from the Department of Civil and Mechanical Engineering (C&ME) at USMA as its foundation[7]. It was the articulation of what and how the senior teacher modeled excellent teaching during 40 years of C&ME demonstration classes at the start of the six-week instructor-training course that led to the teaching model now labeled the ExCEEd Teaching Model (Table 1). The current ExCEEd and C&ME seminars presenting classroom techniques and activities to be summarized below were the direct result of analyzing each component of the teaching model in Table 1. A literature review highlighted the use of Lowman[8] and Wankat and Oreovicz[9] as textbooks for the workshop. The ensuing detailed reference to these two books is provided to efficiently guide the reader interested in further self-study.

Table 1. The ExCEEd Teaching Model

Structured Organization • Based on learning objectives • Appropriate to subject matter • Varied, to appeal to different learning styles
Engaging Presentation • Clear written and verbal communicati • High degree of contact with students • Physical models and demonstrations
Enthusiasm
Positive Rapport with Students
Frequent Assessment of Student Learning • Classroom assessment techniques • Out-of-class homework and projects
Appropriate Use of Technology

II. Daily Classroom Activities

Success in any endeavor requires proper organization, preparation, practice, and rapport. This is especially true in higher education. Without an organized plan for teaching preparation and practice, teaching can easily lose priority relative to research. The preparation and presentation without organization will miss the desired goal of properly educating and then motivating the students to continue in the discipline as a student, an educator, or a practitioner. According to Lowman, “Most excellent instructors plan very seriously, fully aware that alternative ways of organizing class sessions are available, which go beyond the mere presentation of material to the promotion of active higher-order learning and motivation.”[10] And without developing a connection with each student, we could be simply replaced by a book on tape.

II.A. Learning Objectives

All classroom activities should flow directly from the course learning objectives. In general, many professors establish course objectives before the start of the semester. Some may even provide a more detailed list of course objectives beyond what is presented in the course description in the course catalog. Course objectives establish the structure of the course that allows for connectivity between courses and provides insight into what the course is supposed to accomplish.[11] An example of one course objective in a Statics Course covering the analysis of trusses is:

Apply equilibrium equations to calculate internal member forces in trusses.

In order to provide greater focus for the daily activities, the authors establish learning objectives for each lesson. Establishing written learning objectives for each lesson prior to the start of the semester is the key to efficient lesson organization. The learning objectives not only guide lesson development, but also serve as a contract with the students as to what will be covered during the lesson and the semester.[12] There must be at least one objective for each lesson. Generally, three to five lesson objectives are ideal with the action verbs defining the level of desired performance based on Bloom's Taxonomy of Educational Objectives.[13] Lesson objectives for a class on truss analysis could be:

- Define and Identify zero-force members in a truss.
- Solve for the internal forces in truss members using:
  - Method of Joints.
  - Method of Sections.

Formal lesson objectives provide the proper focus for lesson preparation. Ideally lesson objectives should be provided to the students at the beginning of the semester. The first time through a course, individual lesson objectives may need to be developed as you prepare a block of lessons. If this is the case, provide them as a handout at the beginning of the block. At a minimum, place the lesson objectives on the board at the beginning of class or have the students physically refer to them in the syllabus (or recently distributed handout). The lesson objectives then serve as a road map to help the students understand the importance of what is being presented and discussed during each class. Of course, full student understanding of a lesson objective is accomplished through both in-class and out-of-class work (i.e., thru notes, discussions, demonstrations, reading assignments and homework). The listing of lesson objectives at the start of a semester <u>does not</u> preclude a change in the course based on some type of assessment or determined need. Simply providing the rationale for the change and a listing of the new objectives for the changed lessons will quell most student anxiety. Regardless of when the lesson objectives are provided to the students, the lesson objectives must be assessed at the conclusion of each lesson.

II.B. Board Notes

Armed with learning objectives, the teacher develops board notes detailing the activities and material to be presented on the chalkboard (or other medium) always with an eye on what is the irreducible minimum needed. Our classroom (board) notes are not just a stream of consciousness as some professor classroom notes seem to reflect, but bite-size chunks of information linked by effective transitions into a coherent and organized presentation to produce a desired effect.

A lesson is generally considered fully prepared once the professor has developed lesson objectives, studied the material, planned exactly what he or she intends to place where on the chalkboard, acquired the lesson materials (handouts, structural plans, models, demonstrations, etc.), constructed physical models, rehearsed the class, planned in-class group or individual exercises, planned possible in-class assessments, and prepared the associated homework.[14] The key activity is planning what to actually present in class including the material to be placed on the board. According to Lowman, "Teachers who carefully consider what content should be presented and how learning should be organized are more likely to orchestrate virtuoso performances than those who leave much to improvisation."[15]

The development of board notes establishes what material is to be placed where on the chalkboard (Figure 3). Each rectangle represents a section of the chalkboard or reasonable board space. Some board notes pages have 6 sections of material, while others may only have 4 sections. Board notes can be used to plan the entire lesson to include when to do a demonstration or use a model (Figure 4). The third board has a note (i.e., start w/ demo) as a reminder when the physical model (i.e., zero-force demonstrator, Figure 5) needs to be used during an actual class. Some teachers use the left-hand rectangles for the actual chalkboard material and the right-hand rectangles for notes or questions to ask in class associated with the

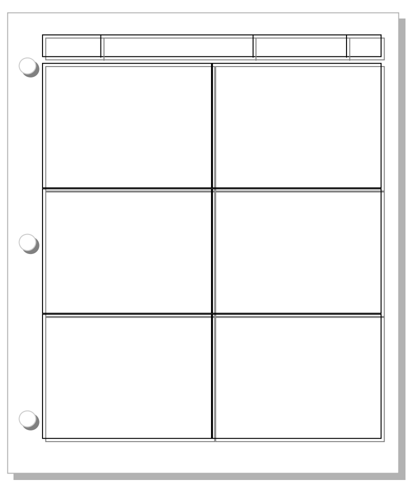

Figure 3. Blank Board Notes Sheet

material in the left-hand rectangle. Wankat relates this to the playwrights putting stage directions in their plays to indicate announcements, reminders, breaks for student activities, alternate solution paths, etc. Normally the posing of good, clear questions, rather than relying on spontaneity, requires thorough preparation.[16] Notice that only the minimum amount of material required to guide the student's learning should be placed on any one board (Figure 4).

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Fully thought-out board notes usually accomplish all but the lesson rehearsal and the development of homework. Most homework usually causes in-depth use of the concepts presented in class (i.e., what is in the board notes). The process of reproducing/thinking through

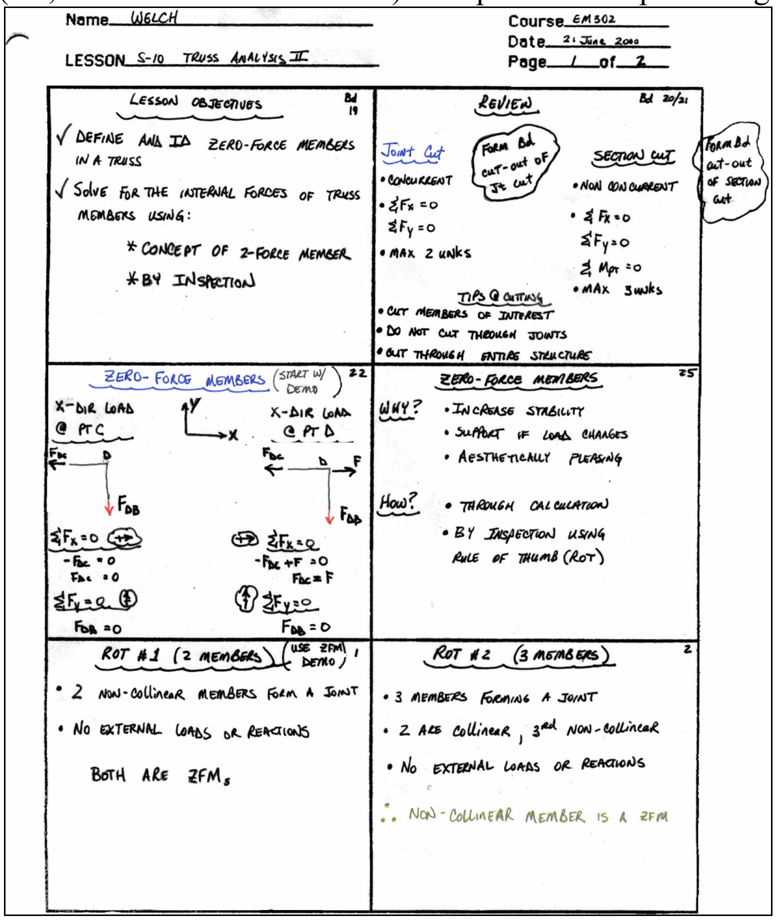

Figure 4. Board Notes For Workshop Demonstration Class

the board notes (i.e., tying together why we present the material in a certain order) will prepare the professor to focus on engaging the students rather than thinking about what or how it should be placed on the board. If during board note development a group exercise is to be incorporated into the class, then the professor must decide if the student desks need to be arranged for the exercise at the beginning or during class. If there is a desire to modify group dynamics for each group exercise, then the professor may want to place name cards (names on folded 5x8 cards) on desks prior to class. Board notes also provide a written record as to what was actually taught during each lesson which is essential during course assessment and future lesson preparation.

II.C. Video/Demo/Physical Models

The activity normally missing in many classrooms are the in-class activities, i.e., demonstrations (Figures 1, 5, 6), experiments, etc., that help the learning to come alive. Whenever possible, have a demonstration or physical model as part of a lesson (Figure 5, 6). Just as with a play, except here the professor is the sole performer, the props greatly assist in the effectiveness of the performance.[17] Simply put - a picture is worth a thousand words. During board note development, the suitability of models or demonstrations should become obvious. Some prep time is usually required to have a proper model prepared or a demonstration set-up in time for a given lesson. Just like with lesson learning objectives, physical models might not be prepared

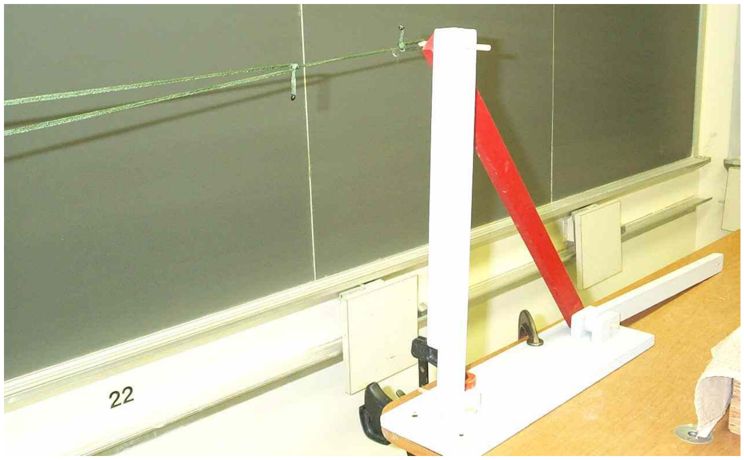

Figure 5. Zero-Force Demonstrator

before a course begins. Unlike lesson learning objectives which should be developed before the lesson is taught, you may not be able to develop a physical model for each lesson. However, a physical model inserted every couple of lessons or at the start of a new block of material would be a great start and over time more and more models and demonstrations can be included.

II.D. In-Class Examples and Activities

Whenever possible, students should apply some of the theory and equations during class through in-class examples, especially in the basic mechanics courses where the fundamentals are established. Whether the in-class problem solving is instructor led, individual work, or group work, the opportunity to wrestle with the material with a trained professional nearby is

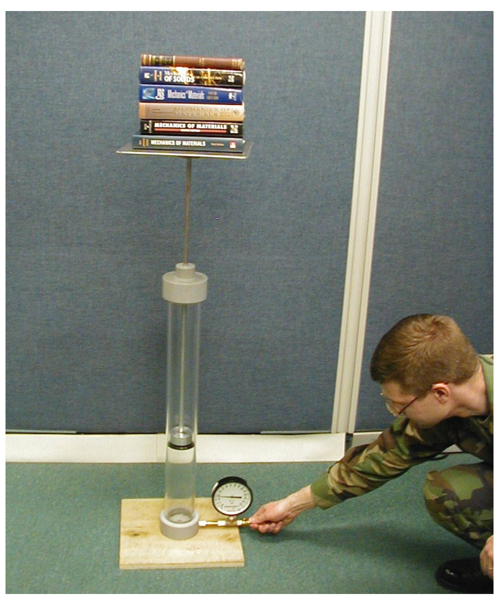

Figure 6: The Stress Demonstrator (on floor here, but best if on a desk)[18]

invaluable. In many courses, out-of-class activities already have a group setting, such as in design work. In the real world engineers do not get to pick and choose who they want to work with. The professor should assign the teams based on some parameter(s) (background of courses, surveyed skills, in-class observations, etc.).[19] The assignment of students to teams should be done early in the semester to allow teams to sit together and work together on in-class and out-of-class group exercises. Learning then truly becomes a team effort throughout the semester. The authors have been known to send students to the chalkboard to solve an in-class problem. This allows one group to present their solution, right or wrong. Each group can see how the other groups solved the same problem. When all in a group are working to solve the same problem at the board, they are more focused. When seated, the instructor has the students all work together placing the solution on an overhead sheet so all are focused on the same task at hand and the solution can be presented, if required. Group work is extremely effective when used in the second or third lesson of a block of lessons – especially when it builds on previously covered fundamentals. Consider the three lessons on truss analysis in ETW: lesson one, method of joints and sections; lesson two, zero-force members; lesson three, analysis of a complicated real bridge. The lessons after the first lesson review previous techniques and provide repetition while adding minor additions to the student's tool bag of skills. Of course, whether you use groups to solve a problem at the chalkboards or at their desks, a solution should be available to hand out so that the students focus on solving the problem at hand rather than trying to copy a solution into their notes.

During class, use the pictures and charts (tremendous aid and saves a great deal of time[20]) in the textbook when explaining equations or concepts. The chart or figure should be displayed on an over-head (or power point slide with scanned picture/chart), but the student should be using their text to look more closely at the figure. The professor should ensure that as much of the board note material as possible is referenced back to the text through written page or equation numbers on the chalkboard. This technique will encourage students to consult the textbook if a point is not clear or if they want more information.[21] Instructors should use notation and symbology on the chalk board that is consistent with that found in the text. If the students have to use the textbook in class, then they will more likely use the text during homework and begin to understand how to self-learn through other available resources.

II.E. Lesson Motivation

The age old question is why should a student pay attention in class or even come to class, especially if the course routine is lecture only and the occasional copying of notes from the chalkboard? So how does a teacher get and keep a student's attention in class? Use quizzes or questioning to put them on the spot and make them stay focused. However, it is not our job to make them learn, but to motivate and inspire them to want to learn. There are only a limited number of lessons during each semester for professors to properly cultivate learning within their students. When a professor walks into class, opens up the course folder to the sticky note marking the spot the previous lesson stopped, and begins at that point to try and determine what to discuss in class, precious student contact time is wasted.[22] The lesson can quickly disintegrate into a stream of consciousness with an occasional concept being placed in any empty space available on the chalkboard. Besides rehearsing the lesson based on the board notes for the lesson, what is needed is a “grabber” – something at the beginning of class to stimulate the student’s curiosity for the current lesson.[23] Maybe the “grabber” is a physical demonstration (like

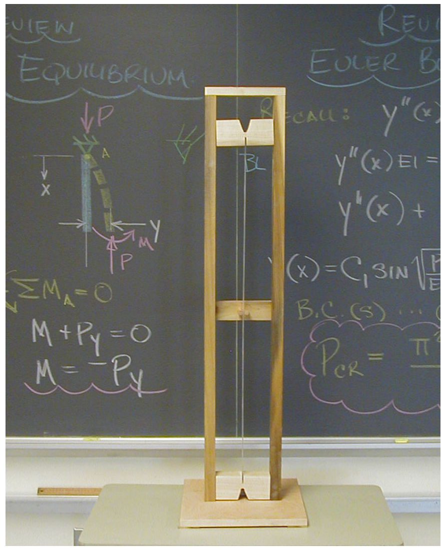

Figure 7: The Buckling Demonstrator

for buckling in Figure 7), a great model (Figure 8), or video clip. For example in Dynamics, a video of drag racing or the catapults being launched in The Gladiator will be used before the lessons on applications of Kinetics where the in-class example is a dragster on one day and a catapult (Figure 8) the next.

Figure 8: The Catapult

II.F. Questioning

There are many who feel that developing rapport with the students in each course they teach is unnecessary, but those students who enjoy the time they spend with their professor will enjoy the classroom environment. They are actively engaged in class and feel they learn more.[24] Lowman considered interpersonal rapport so important that it became one dimension of his twodimensional model for effective teaching.[25] Previously, questioning was considered to put students on the spot and to force them to learn. However, the use of questioning to encourage students to use previous knowledge to develop new knowledge through active participation with the instructor and the class also helps develop rapport. [26,27]

Active education implies engaged students throughout the lesson. The best technique is to train the students to expect questioning during the lesson. Ask the question, pause, and call on a student using their first name.[28] Once trained, the simple act of posing a question will heighten everyone's senses, keeps all students "at risk"[29], and cause them to think about an answer for the question. Once the students know that you will call on everyone, call on each student more than once each lesson to ensure that they do not disengage once they arrive for class or answer their first question.[30] Keep the students on the edge of their seat. Challenge them. Asking questions also slows down the presentation to allow students to ponder or catch up on note taking. Once the professor asks questions, the students will eventually be encouraged to ask the professor questions based on intriguing course material – and then true learning begins. Asking each student a question each lesson shows that you care about their learning and want to include them in the learning process.

Effective questioning implies knowing your students names. It is hard to encourage learning when you say, "What are the assumptions implied by the model for the analysis of trusses?", and then point at a student randomly, or do like some professors, who look for a hand, and when no hand is raised, just answer the question themselves. Learning student's first names greatly assists in developing personal rapport in the classroom. Questioning is more effective when the professor can call on a specific student for specific questions.[31] It allows the faculty to greet students in a more personable way around campus or town. The simple requirement to have a students first name on a folded 5x8 card on the desk for one or two weeks is generally all that is required to learn everyone's name. When possible, student names should be learned by the second class. A few great teachers are known to stop the first lesson early to videotape or photograph each student as they depart. This visual aid with the student saying the name they want to be called provides for a more rapid face to name recognition.

II.G. Just In Time Learning

Just in time learning is a variation from the normal schedule of activities listed above. Class starts with a motivator for the lesson and jumps directly into the example problem. Using the skills that the students already possess, they begin to solve the problem. As they encounter a problem or concept that they have not experienced before, the teacher asks questions as to what tool or theory they might need to press on with solving the problem at hand. At that point the instructor presents the required theory and tools to get back to solving the problem.

II.H. Schedule Course in Proper Classroom

How a professor plans to conduct the class and engage the students dictates the proper type of classroom setting and location. Lowman states, "College classrooms are dramatic arenas first and intellectual arenas second."[32] Maybe that is why many classrooms have raised platforms near the board and overhead lighting to improve student observation of the professor during active learning. If a professor desires to conduct in-class small group exercises, an auditorium probably is not the best choice. Either individual student desks or large tables with multiple chairs may be more suitable. The equipment in the room to include the amount of black board space, projection systems, etc. may limit how course material is presented. Is the classroom close to a laboratory or is there classroom space in the laboratory if experiments are part of the lesson objectives? Is there space in the classroom for large models or demonstrations? Is the course covering design or is it a seminar?[33] All of these (and many more) issues affect the learning environment for the course. Do not forget things like climate control, external noise or built-in distractions like a window view of a sports field.

Even though there is an appearance at some universities that funding is only sought for research facilities rather than maintaining or upgrading existing classrooms, professors must still seek out and demand classrooms that are conducive to learning if they are going to be able to establish the proper learning environment. Where is the future researcher nurtured initially? - In the classroom. The professor constantly must consider the intellectual and emotional objectives that can be accomplished in class.[34]

II.I. Schedule Realistic Course Preparation Time

Each professor must organize her time to meet the requirements for both research and teaching. As with research, effective teaching requires time to prepare, practice, grade, and be available to students (i.e., office hours) for out-of-classroom assistance. Each professor has a threshold of required time to effectively teach a given lesson. A large amount of time is usually essential in preparing the lesson for the first time. Learning how to teach effectively before teaching that first class can significantly reduce the amount of time required to feel comfortable and prepared to teach any lesson.[35] Enter onto the scene teaching workshops like the ExCEEd Teaching Workshop. Even less time may be required if minor modification (based on assessment of lesson objectives, content, models, demonstrations, etc.) is required the second time a lesson is taught. Bottom line, professionalism should drive each of us to provide the time necessary to prepare each lesson properly.

II.J. Rehearsal

A professor who has been teaching the same course for a large number of years may be able to walk into a lesson with little to no practice and present the material in an effective, flawless manner, while accomplishing the desired student reaction to the material. For the majority, some type of practice or in-depth review of the material is required. Who has the time? All of us must make time! Few of us are brave enough to walk into a conference without developing the slides, reviewing the order of the slides and thinking through what we plan to say. The same process must be used before presenting a lesson. Enough time must be set aside to ensure that the professor is confident about what, when, where, why and how material is to be presented to achieve the desired effect.

Actors and actresses start with a script (board notes) and rehearse.[36] In the same way, a professor must rehearse to use the time available during a class as efficiently as possible. Good teachers will physically or at least mentally walk-through a prepared lesson one or two times prior to class. The last rehearsal may be on the way to class if it is not in the same building as your office. The lesson should have a certain flow to it with the questioning of the students (active teaching) used to not only lead the development of chalkboard material, but to provide the transition (i.e., stage directions[37]) between lesson topics. The class should be organized, well thought out, energetic, and fun. Just think about some of the great lectures or classes you have been to, and then think about some of the worst. Even if the material was interesting, poor delivery had a huge negative impact.

The authors used the physical reproduction of the prepared board notes in the desired colors of chalk (using pens) as part of their mental rehearsal of the class. Difficult charts and figures to be presented on the chalkboard should be physically practiced at least once before the class (i.e., full dress rehearsal). It is amazing how difficult it is to recreate a complex chart or 3D picture on a chalkboard. Some would argue, why not just use an over-head or PowerPoint slide of the picture or chart? If the completed chart from the textbook is the end result, then why not, but if the development of the chart is part of the learning process, then the chart must be developed on the board. It is usually important to have an accurate figure on the chalkboard when done, and that requires practice.

Group exercises, demonstrations, and models will not have the desired affect if not planned and practiced. In fact, they may enforce a wrong concept if not executed properly or possibly embarrass the professor when they do not work or have missing pieces. The professor must be intimately familiar with all exercises, demonstrations, or models used during class.

II.K. Instructional Technology

All that has been stated concerning rehearsing the use of demonstrations, experiments, and physical models is equally true when using instructional technology, which includes the use of the chalkboard. Computer programs are superb for showing simulations and answering "what if" statements quickly. Rehearsal is critical to ensuring that valuable class time is not wasted while the professor tries to remember how to use the program or manipulate the data. With today's computer savvy students, the simple act of showing the use of a computer program in class is all that is needed for many students to begin using the new technology to expand their knowledge.

II.L. Other

Presented here are a couple of concepts that make the classroom a better learning environment for students. They appear obvious, but after reflecting on graduate school experiences, the authors are not sure how obvious they really are.

Smile - If a professor does not enjoy teaching, he/she should change professions. It is extremely important that students see the faculty enjoying teaching.[38] A smile is a great invitation to join the learning process, to try to answer the question posed, and to ask a question that is probably on other's minds. Students are more likely to participate if they view the professor as friendly. When you walk into the classroom or a meeting for after class assistance, there is <u>NO</u> other place in the world you want to be. Make the student feel that they are important to you.

Get to know your students - Get to know more about who your students are by using a student survey on the first day of class. Ask them what is their favorite movie, song, performing group, sport, university activity, etc. Who knows, you just might have something in common with them. Let the students know the results of the survey to show that you actually reviewed the information they provided. Usually there are a few unique anonymous responses that will provide instant humor in any setting. If activities that interest you are added to your schedule, then something that is fun for you can also be used to connect with your students.[39] A thumbs-up at the event for a great performance or personal comment before class starts or a class wide comment enlisting the future support of more students for an event, can help the students to connect with the faculty, and eventually learning.

III. Assessments

All these techniques sound good and probably were easier to implement at the turn of the century prior to the heavy emphasis on research. However, these principles are equally important today as students need the professor to help them better understand concepts through the use of appropriate technology and classroom techniques that produce an engaging classroom environment.

The importance of demonstrations and physical models is demonstrated in the results from a Mechanics of Materials course where the instructors deliberately increased their use.[40] Lowman contends that demonstrations, which he calls lecture-demonstration classes, are essential in engineering and science courses.[41] We could not agree more, and both anecdotal and statistical data from the course supports this contention. Student response during the demonstrations was always strong, and inspires a high volume of questions - a clear sign of student engagement! Most of the demonstrations described by Vander Schaaf and Klosky were put into use in the Fall of 2001, and were not used in the Fall of 2000. The semester-end survey responses for instructors related to visual connection showed a strong upward trend between the two semesters (see Figure 9). This is significant because the instructors, course content and student population composition remained fairly constant between these two semesters. When speaking with students in later semesters, the strongest recollections of any course are the physical demonstrations rather than specific equations.

Student comments also supported the use of demonstrations:[42]

- "The instructor uses extremely effective learning tools in class, and they really helped me to better understand the material presented."
- "This has been my favorite class... Even though it was more work than any other class, it really stimulated my learning and excitement of being a Civil major."
- "Good visual aids"
- Q: Strengths of course. A: "The instructor demos and visual aids", "Practical applications", "Interesting material, vital to Civil and Mechanical majors", "Made difficult concepts easy and applicable"; "Relevance to practical applications/life"; "very practical material".

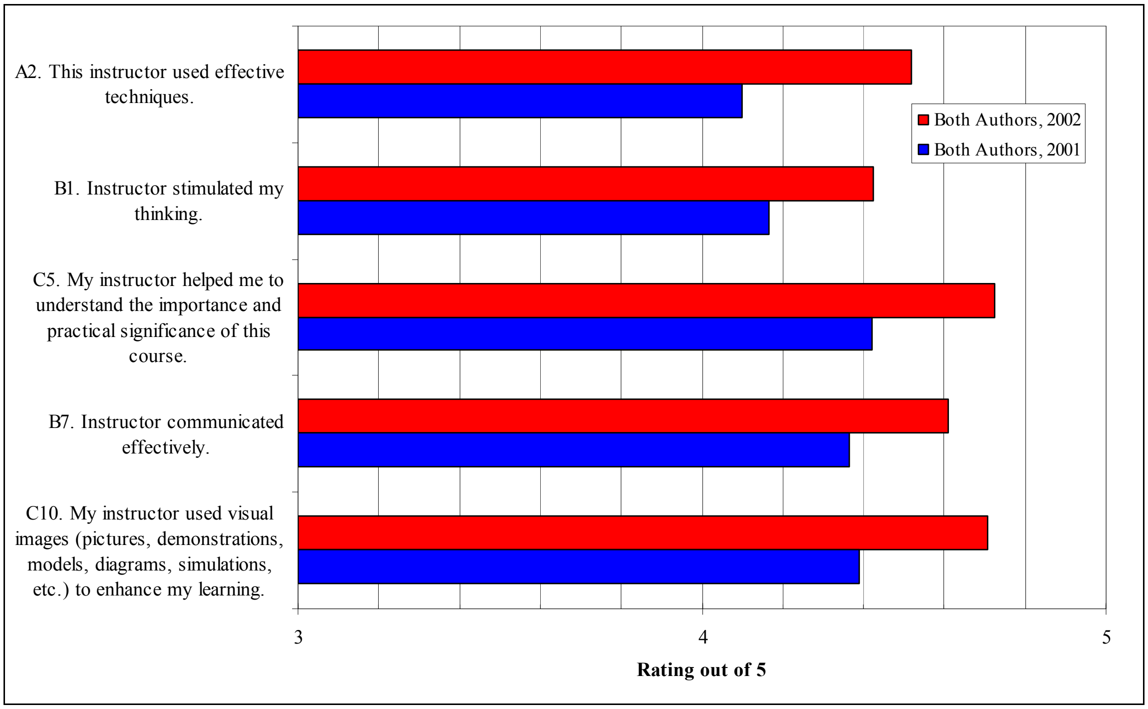

Figure 9: Assessment Data for Fall 2001 and Fall 2002[43]

Additional evidence for these techniques can be found in the formal assessment data from the ExCEEd Teaching Workshop. Figure 10 presents the survey data collected from participants during their second semester after attending the ExCEEd Teaching Workshop at West Point. For each topic they note the contribution of the daily classroom activities taught during ETW to their overall success. Generally it could be noted that the group in 2003 possibly experienced less contribution for their success from presented techniques. However, the real measure must take into consideration the start point of the participants before ETW as shown in Figure 11. Upon comparison of the long-term results for each group of participants, the delta between before and after results for each category has been relatively consistent since the workshops began in 1999.

Lesson organization (board notes), presentation of material (board notes), student interaction (through questioning), use of demonstrations and visual aids, and energy and enthusiasm (for teaching) constantly lead to improvement in teacher confidence and student evaluations.

IV. Benefits

Teachers using these techniques truly enjoy teaching. They are more relaxed and enthusiastic in the classroom, partly due to experience of ETW, but mostly due to the techniques learned and applied at their home institution. While some are born with innate qualities that make them good teachers. This paper summarizes several objective approaches to improve any faculty member's teaching ability. Ultimately, it is the students who benefit most from these techniques being applied in the classroom.

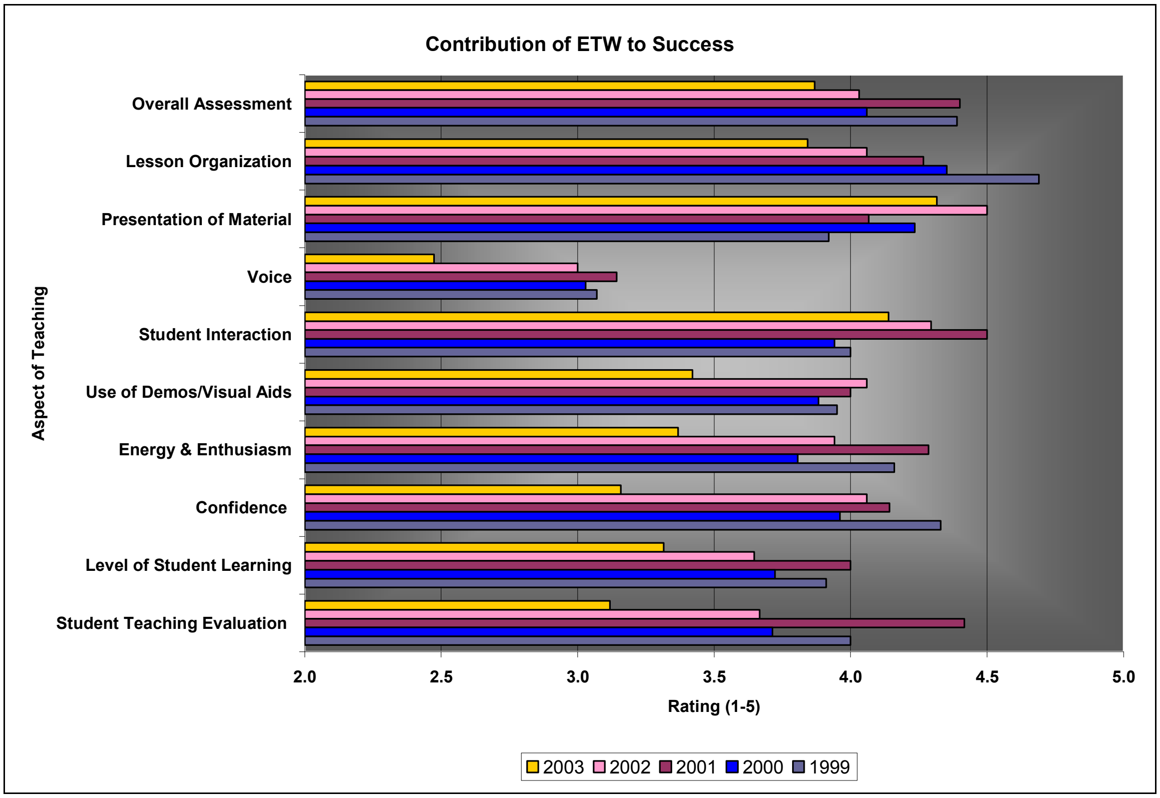

Figure 10. Contribution of ETW to Success

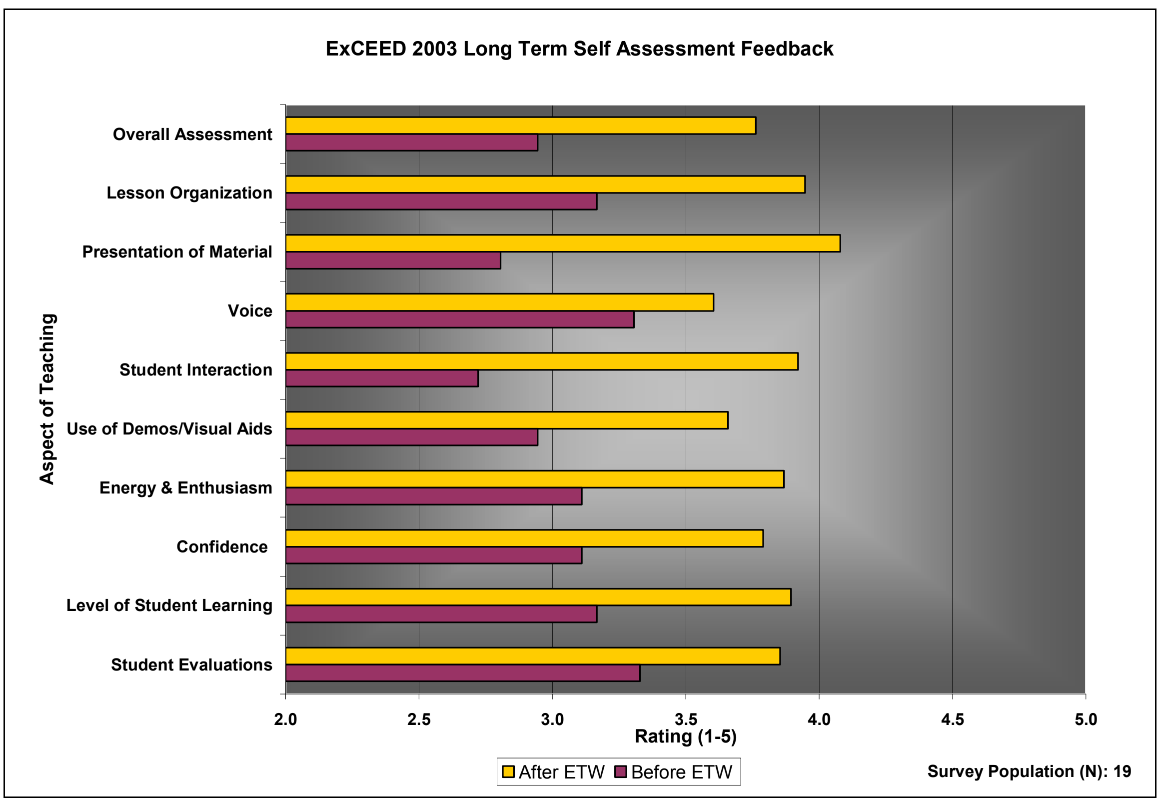

Figure 11. ExCEEd 2003 Long Term Self Assessment Feedback

Although revising classroom routines to incorporate the presented teaching principles is a significant investment in time, the instructors ultimately find they are more effective in teaching preparation activities. A great deal of time can be saved when preparing in an efficient and effective manner such as with board notes, etc. This allows the instructor to move beyond their preparation and look more closely at the student. How are they doing? Is the pace right for them? Do they understand? Who is having trouble? They look for continued improvement in teaching efficiency as they gain experience. The methods discussed in this paper are adaptable to any engineering professor's individual teaching situation. Overtime, improved efficiency in lesson preparation, especially in previously prepared lessons, eventually equates to improved teaching and increased research time.

Teaching takes place only when the students are learning. Many equate teaching with the act of presenting material in a lecture. This paper shows how to organize a class, effectively present the material, and establish good rapport with the students. The improved rapport with students makes being a faculty member more enjoyable and increases student learning. Generally, the classroom is filled with laughter as the students have fun and get caught up in the professor's excitement for the subject material.

A number of the instructors applying these techniques have been nominated for and won teaching awards. The accolades provided to the instructors have increased from both peers and students alike. Some peers are now adopting techniques (i.e., board notes, models, demonstrations, etc.) for their own use.

V. Conclusions

Every professor and every teaching assistant would certainly benefit from formal instructor training. The granting of a degree (Ph.D. or M.S.) does not automatically bestow teaching skills, especially effective teaching skills. Most professors simply try to emulate observed styles without any justification as to the effectiveness of different teaching styles. The lack of formal training programs at most universities, and nearly nonexistent programs to provide constructive criticism from peers relegates most faculty to the very slow process of developing effective (if they are lucky and persistent) teaching styles through a long career of trial and error. Add the demands of research and the priority at many universities of the greater importance of research over teaching, and it is easy to understand the reason for the large number of ineffective teachers at the college level. However, it only takes a relatively small amount of focused effort in an exceptional program like ETW to lay the necessary foundation to become an effective teacher, as presented in Figures 10 and 11. Even though the workshop does not have to necessary look exactly like ETW, the workshop must present the principles of effective teaching (i.e., presentation skills and class organization), demonstrate effective teaching styles and techniques, and require the participants to practice their skills under a mentor's gaze and assessment.

These concepts for successful teaching in our basic mechanics courses (and all others as well) were presented as a synopsis of the key ingredients of the ETW workshop. These concepts are not provided as a replacement for this exceptional program, but as a reminder of some of the key points to being successful as a teacher and to serve as a starting point for those waiting to get into a teaching workshop. There is no replacement for actually teaching a class under a mentor's gaze and learning through a personal assessment of the class. For more information concerning the ExCEEd Teaching Workshop, see www.asce.org/exceed.

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